9003

DU MONT

PULSE GENERATORS

TYPES 404 and 404-R

llen B. Du Mont Laboratories, Inc.
TECHNICAL PRODUCTS DIVISION
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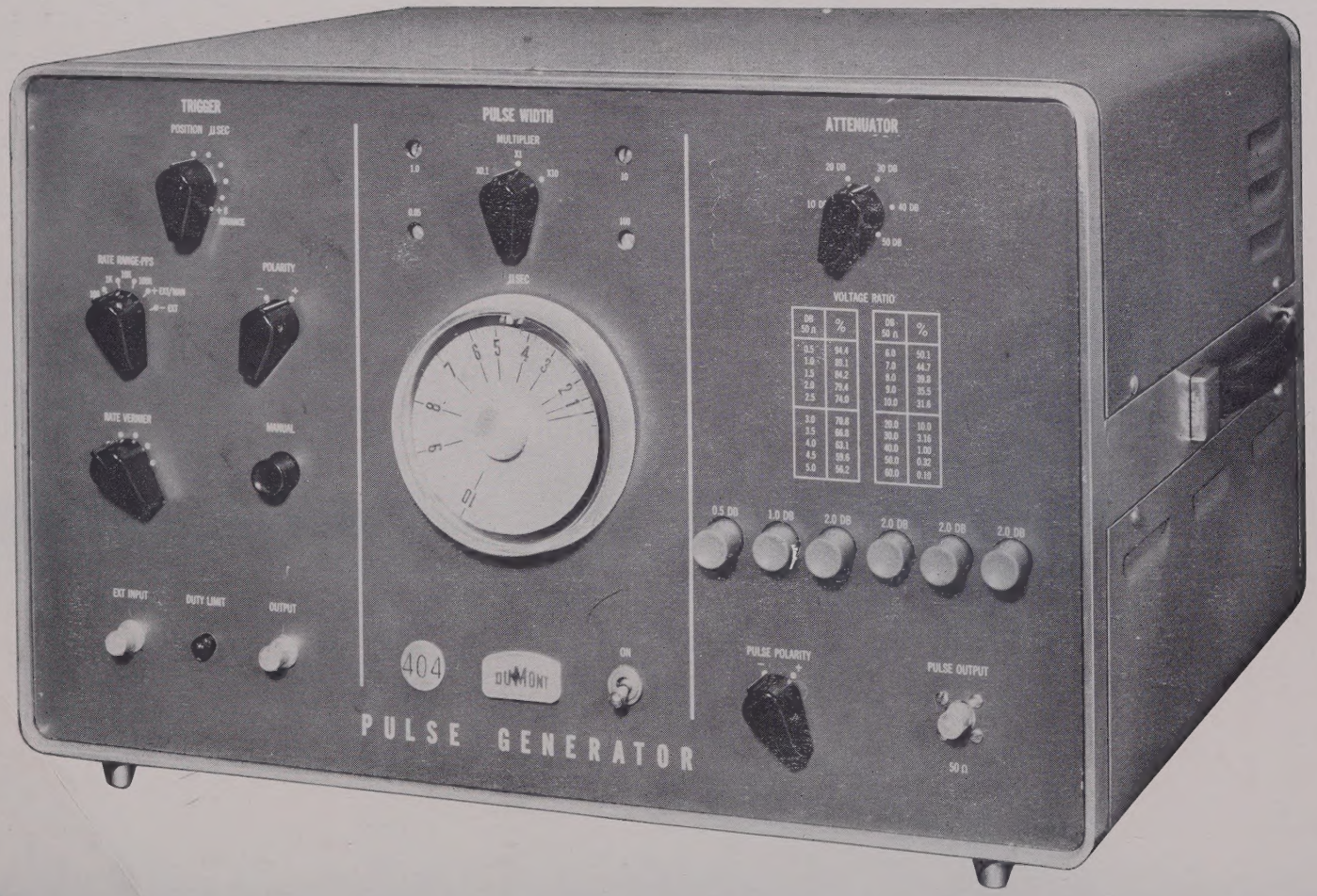

Du Mont Type 404 Pulse Generator

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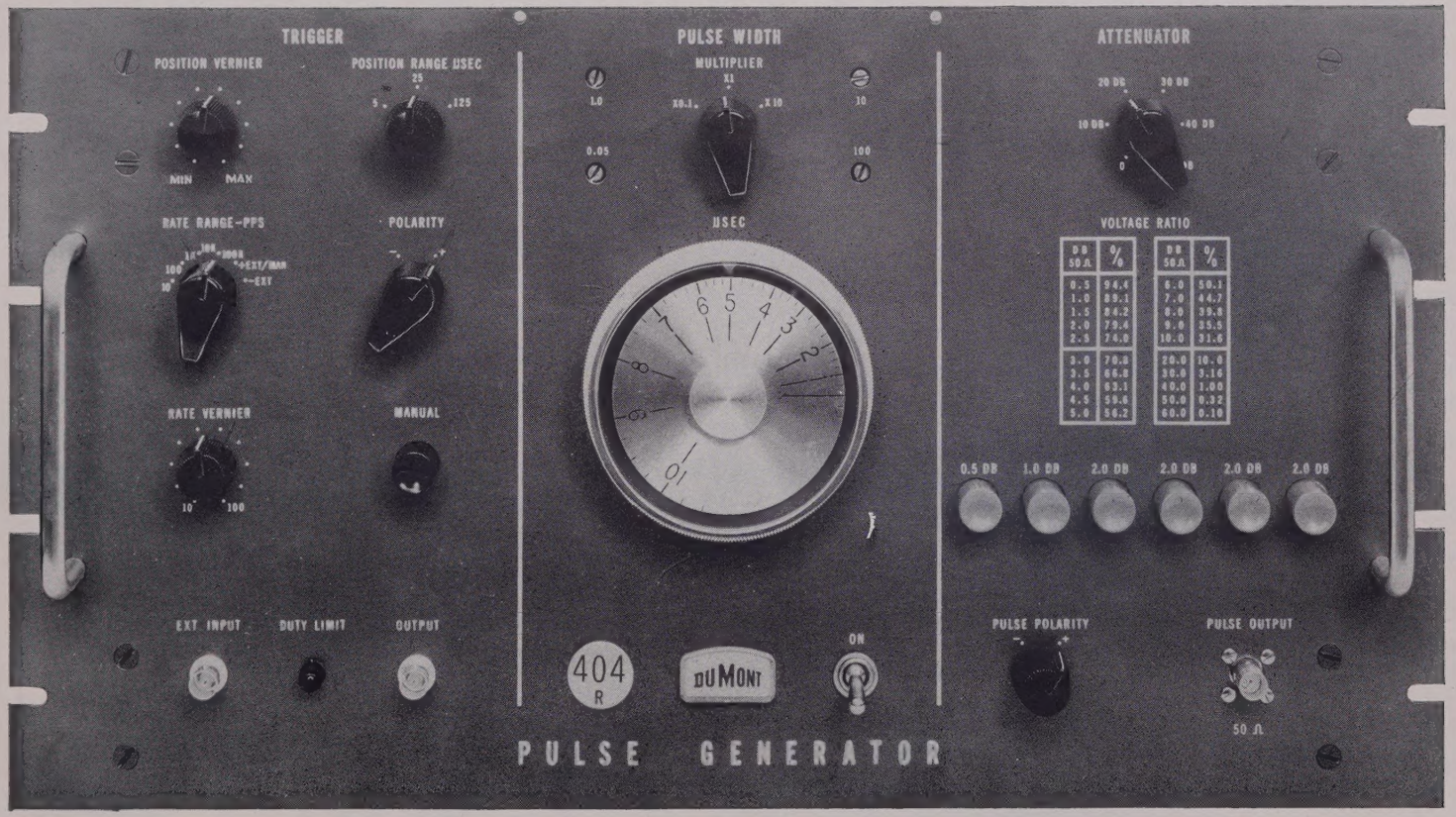


Figure 1-1. Type 404-R Pulse Generator

SECTION 1
TECHNICAL SUMMARY

1-1. INTRODUCTION

This manual of operating and maintenance instructions contains information on both the Type 404 (bench model) and Type 404-R (rack mounted) Pulse Generators. Electrically, the two types are identical; mechanically, they differ in exterior appearance. These differences are clearly indicated in the text. Otherwise, references throughout the manual to the Type 404 pertain also to the Type 404-R.

1-2. PURPOSE

The Type 404 is a general purpose Pulse Generator providing good-quality pulses of useful level for most applications. This instrument generates pulses ranging in width from 0.05 microsecond to 100 microseconds, with repetition rates up to 100K pulses per second at combinations of pulse width and repetition rate up to 10% duty cycle.

1-3. FEATURES

- Good-quality pulses variable in width from 0.05 to 100 microseconds.
- Repetition rates from single pulse operation (MANUAL) and continuously variable from 10 to 100K pulses per second (internal or external initiation).
- Positive overload protection eliminates danger of damaging the instrument, regardless of control setting.
- Jitter-free OUTPUT trigger available to initiate external equipment before or after pulse start.
- Precision ladder attenuator, controls pulse amplitude in 0.5 db increments, from 0 attenuation to 59.5 db down.
- PULSE OUTPUT start can be advanced up to 2 microseconds or delayed up to approximately 125 microseconds with respect to the delayed trigger OUTPUT.

TABLE 1-1
TECHNICAL SUMMARY
DU MONT TYPES 404 AND 404-R PULSE GENERATORS

1. PULSE OUTPUT	
a. Amplitude	
(1) Peak voltage	50 volts, ±10% (with termination)
(2) Overshoot and ring	Not more than 3%
(3) Attenuation	ATTENUATOR enables reduction of pulse amplitude in 0.5 db increments to 59.5 db
(4) Incremental accuracy	±3% each step of the ATTENUATOR
b. Polarity	Switched positive or negative
c. Output Impedance	50 ohms
d. Duration	
(1) Width	0.05 μsec to 100 μsec, continuously variable; minimum width can be calibrated at front panel
(2) Rise or fall time	18 milli-μsec maximum
(3) Duty cycle	10% maximum with prevention of operation beyond specified duty cycle

TABLE 1-1. TECHNICAL SUMMARY (Continued)

e. Repetition Rate

(1) Internal	10 pps to 100 pps, ±10%, uncalibrated
(2) External	Can be triggered by pulses having the following characteristics: Amplitude: from 2 to 100 volts peak Polarity: positive or negative Rise time: 1 μsec or less Rep rate: single transients to greater than 100 pps
(3) Manual	Push button provides single pulse of selected width and amplitude

2. TRIGGER OUTPUT

a. Amplitude	25 volts minimum when properly terminated
b. Duration	
(1) Width	0.1 μsec
(2) Rise time	0.05 μsec
c. Output Impedance	50 ohms
d. Polarity	Switched positive or negative
e. Jitter With Respect to PULSE OUTPUT	2 milli-μsec or 0.04%, whichever is greater, depending on pulse position
f. Delay With Respect to an External Trigger	Fixed, 5 μsec, ±10%

3. PULSE POSITION

a. Internal, External, or Manual Operation	PULSE OUTPUT start can be advanced up to 2 μsec or delayed up to approximately 125 μsec with respect to the delayed trigger OUTPUT
b. Delay of PULSE OUTPUT With Respect to an External Trigger	3 μsec minimum to approximately 125 μsec maximum (measured with respect to the 10% point on the leading edge of an external trigger)
c. *Pulse Delay Duty Cycle	80%; for example, at a repetition rate of 100,000 pps, PULSE OUTPUT start can be delayed up to 4 μsec maximum, with respect to the delayed trigger OUTPUT; up to 9 μsec maximum, with respect to an external trigger or to the undelayed internal trigger

* Pulse delay interval is defined as the time between the internal or external trigger and the start of the output pulse

4. POWER REQUIREMENTS

a. Primary Source	115 volts, ±10% (230-volt unit available upon request)
b. Primary Frequency	50-60 cycles
c. Power Consumption	600 VA

5. SIZE AND WEIGHT

	Type 404	Type 404-R
a. Height	10½ inches	10-15/32 inches (panel)
b. Width	17½ inches	19 inches (panel)
c. Depth	16 inches	15-7/32 inches
d. Weight	55 pounds	55 pounds

SECTION 2
OPERATION

2-1. GENERAL

The Du Mont Type 404 and 404-R Pulse Generators are shipped with all tubes in place and ready to operate.

Since these instruments are portable, no special installation procedure is required. The —R model has a front panel 19 inches wide by 10½ inches high for mounting in a standard relay rack or cabinet.

2-2. ENERGIZING THE EQUIPMENT

To place the instrument into operation, plug the power cord into the proper power source and turn the power switch to ON. Allow approximately one minute for the instrument to warm up.

2-3. OPERATING HINTS

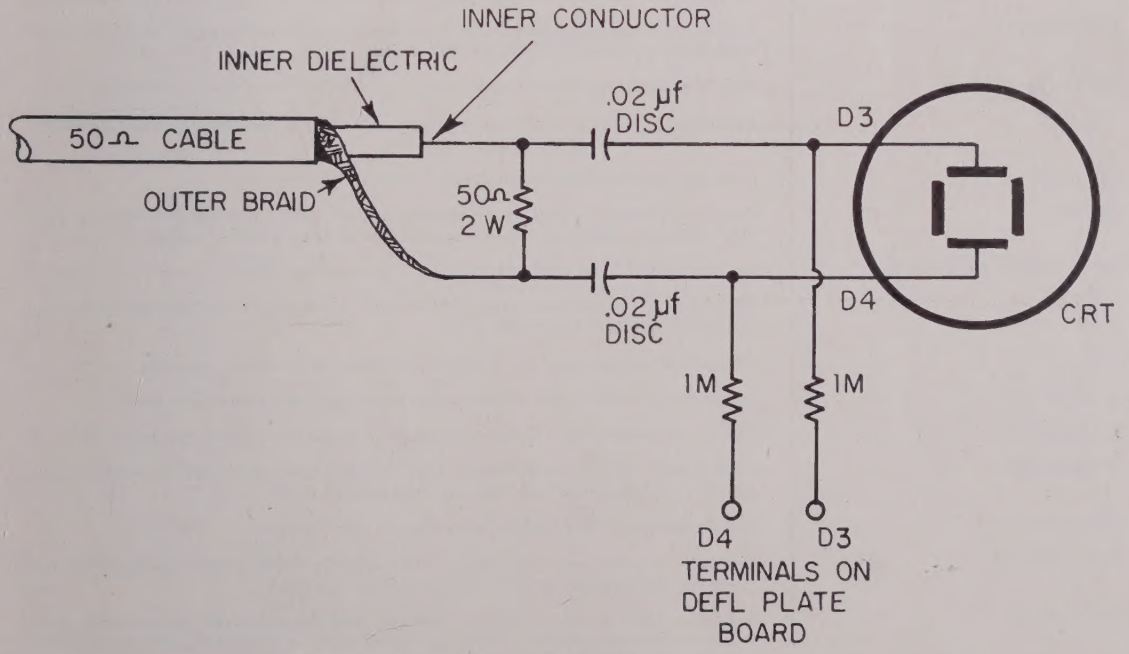
a. General

The operation of this unit is very simple. Connect a length of 50-ohm cable with a BNC plug at one end to the PULSE OUTPUT terminal. The other end should be terminated with a 50-ohm resistor either by the load impedance of the circuit receiving the pulse or by means of an appropriate terminating connector. Pulse width, amplitude, delay, and repetition rate are set according to the desire of the user.

b. Cables and Termination

When dealing with fast, high quality pulses, the importance of impedance matching cannot be overemphasized. Interconnecting cables used with the Type 404 Pulse Generator must have 50-ohm characteristic impedance and must be terminated with a pure 50-ohm resistance in order to preserve optimum pulse waveform.

The method of termination and interconnection is also important. All junctions should be made up of coaxial plugs and connectors. Terminations should also be coaxial, even to the extent of using "T" connectors to provide plugged on terminations with a



NOTE : DISTANCE BETWEEN END OF CABLE AND CRT HELD TO MINIMUM POSSIBLE

Figure 2-1. Method for Viewing Pulses Direct at Cathode-ray Tube Plates

minimum of discontinuities. Failure to observe these precautions can result in severe distortions of pulse waveshape.

c. Pulse Width Calibration Adjustments

The complete pulse width calibration procedure is given in Maintenance, Table 4-2. However, reference to this procedure should be resorted to only if the instrument cannot be calibrated properly by means of the four front-panel screwdriver controls: 0.05, 1.0, 10, and 100 μsec controls. To make sure that the width of the pulse is in agreement with the front-panel markings, proceed as follows:

1) Connect a properly terminated cable between trigger OUTPUT and the external sync terminal of a cathode-ray oscillograph; and between PULSE OUTPUT and the vertical input of the cathode-ray oscillograph.

2) Set the μSEC dial to 1 and PULSE WIDTH MULTIPLIER to ×0.1.

TABLE 2-1
FRONT PANEL FACILITIES

NAME	FUNCTION
TRIGGER POSITION VERNIER	Control: used in conjunction with POSITION RANGE switch to permit continuous adjustment of the start of the OUTPUT PULSE with respect to the fixed trigger OUTPUT signal
TRIGGER POSITION RANGE μSEC	Switch: used in conjunction with POSITION VERNIER control to provide three overlapping ranges for adjusting the start of the OUTPUT PULSE
RATE RANGE—PPS	Switch: performs three functions—1) selects the internally generated triggers in decade steps from 10 to 100K pulses per second, 2) sets up the instrument for amplifying signal applied to EXT INPUT when switch is set to +EXT/MAN or —EXT, and 3) permits the instrument to be driven manually when switch is set to +EXT/MAN
RATE VERNIER	Control: provides continuous variation of the internal repetition rate within the limits established by the RATE RANGE—PPS switch
POLARITY	Switch: switches the fixed delayed trigger OUTPUT either positive or negative
MANUAL	Push-button switch: provides single trigger and pulse of selected width and amplitude when instrument is set for manual operation
EXT INPUT	Terminal: provides for a connection of external triggers
OUTPUT	Terminal: provides a positive or negative trigger, that has a fixed delay of 5 μsec with respect to either the internal rate generator or an external trigger
PULSE WIDTH MULTIPLIER	Switch: multiplies the μSEC dial settings in decade steps of 0.1, 1, and 10
μSEC	Control: provides continuous variation of pulse width within the limits established by the PULSE WIDTH MULTIPLIER switch
0.05	Screwdriver control: used for setting up minimum pulse width—see text
1, 10, & 100	Screwdriver controls: used for setting up maximum pulse width—see text
ATTENUATOR	Rotary switch: provides 10 db step reduction of pulse amplitude up to 50 db
ATTENUATOR	Push-button switches: used in conjunction with the rotary attenuator to enable reduction of pulse amplitude in 0.5 db increments to 59.5 db
PULSE POLARITY	Switch: switches PULSE OUTPUT either positive or negative
PULSE OUTPUT	Terminal: provides an output pulse of controllable width, amplitude, position, and repetition rate according to the desires of the operator
DUTY LIMIT	Indicator: flashing light warns the operator that the instrument is operating at its maximum specified duty cycle and that either the pulse amplitude and/or repetition rate must be reduced
Power ON	Toggle switch: applies primary power

3) Adjust the 0.05 μsec control to obtain a minimum pulse width of exactly 0.1 microsecond as viewed on the cathode-ray oscilloscope.
4) Set the μSEC dial to 10.
5) With the PULSE WIDTH MULTIPLIER set to ×0.1, adjust for a maximum pulse width of 1 microsecond by using the 1 μsec control.
6) Set PULSE WIDTH MULTIPLIER to ×1 and adjust for a maximum pulse width of 10 microseconds by using the 10 μsec control.
7) Set PULSE WIDTH MULTIPLIER to ×10 and adjust for a maximum pulse width of 100 microseconds by using the 100 μsec control.

d. Direct Connection To Deflection Plates (See Figure 2-1)

When applying pulses directly to the deflection plates of a cathode-ray tube, the shape of the pulse is not limited by the response of the built-in amplifier. Instead, it is dependent upon transmission line losses, input capacitance to the deflection plates terminals and/or transit time of the electron beam between the deflection plates. The need for proper termination is accentuated when viewing pulses direct on high-impedance deflection plates. In many cases, using the deflection plate terminals provided by cathode-ray oscilloscope manufacturers is unsatisfactory because of the long leads from the terminal board to the deflection plates. Figure 2-1 indicates the proper hook-up for viewing pulses directly at the deflection plates of a cathode-ray tube.

2-4. FRONT-PANEL FACILITIES

The front-panel markings are essentially self explanatory, and after reading Table 2-1, the operator should be able to master the controls with a minimum of practice.

SECTION 3
THEORY OF OPERATION

3-1. GENERAL

The Type 404 Pulse Generator uses hard tubes for pulse generation. This instrument features repetition rates of 100,000 pulses per second; pulse widths from 0.05 to 100 microseconds, continuously variable; approximately 18 milli-microseconds transition time; and 50-volt output across a 50-ohm load with provisions for accurate control of amplitude in 0.5 db increments, up to 59.5 db.

An over-all functional block diagram of the instrument is shown in Figure 3-1 and a simplified timing diagram in Figure 3-2. It is recommended that the schematics at the rear of the manual be referred to in following the circuit description. For information on service adjustments, refer to Maintenance, Table 4-2.

To simplify circuit analysis, the instrument can be divided into five basic sections as follows: (1) Synchronizer, (2) Timing and Pulse Generator, (3) Pulse Driver and Output, (4) Attenuator, and (5) Power Supply and Heaters.

3-2. SYNCHRONIZER

a. Internal Trigger Operation

The purpose of the synchronizer is twofold: 1) to produce a reference or starting trigger at time t_0 for subsequent initiation of the instrument, and 2) to produce an OUTPUT trigger having a fixed delay of approximately 5 microseconds with respect to the trigger at time t_0.

The internal rate generator (V101A & V101B) is a free-running multivibrator. Waveform **A** at the plate of this stage is differentiated by C115 and R114 and is clipped by CR101, resulting in waveform **B.** The leading edge of waveform **B** is coupled through the series triggering diode (V103A) to the output trigger delay multivibrator (V104) which generates waveforms **C** and **D.** Waveform **D** at the cathode of V104 has a fixed duration of approximately 5 microseconds and is differentiated by C119 and R123. The delayed positive trigger of waveform **E** is used to initiate a blocking oscillator (V105 and T101) which generates waveform **F.** Waveform **G** is the fixed delayed trigger OUTPUT occurring at time t_1, and is switched positive or negative by the POLARITY switch setting.

b. External Trigger Operation

When the RATE CHANGE—PPS switch is set to —EXT or +EXT/MAN, V101A and V101B are converted to a two-stage amplifier for amplifying signals applied to EXT INPUT.

V102A functions as a phase splitter and is switched into the circuit to precede the external trigger amplifier (V101A & V101B) when the instrument is set for external triggering. The phase splitter is operated as a class "A" amplifier with equal plate and cathode loads for equal positive and negative outputs. For external trigger operation, the output of V102A must always be negative in order to initiate the circuits which follow.

c. Manual Operation

The Type 404 Pulse Generator can be driven manually at a repetition rate determined solely by the operator. Depressing the MANUAL push button provides a single pulse of selected width and amplitude. Circuit description is as follows: when the RATE RANGE—PPS switch is set to +EXT/MAN, the manual circuit is connected to the input of V101A. When the MANUAL button is not actuated, C101 is charged to the full potential of the negative supply. After the MANUAL button is depressed, C101 is suddenly discharged through R105. The resulting negative impulse is amplified by V101A and V101B. From this point on, the instrument is driven through the pulse-generating cycle as explained elsewhere.

3-3. TIMING AND PULSE GENERATOR

a. Pulse Delay Circuit

The purpose of the pulse delay circuit is to produce a trigger which occurs to to approximately 125 microseconds after time t_0. This enables the start of the OUTPUT PULSE to be advanced up to 2 microseconds or delayed up to 125 microseconds with respect to the delayed OUTPUT trigger in three overlapping ranges.

Waveform **B,** occurring at time t_0 is coupled through a series triggering diode (V103B) to the variable trigger position multivibrator (V201) which generates waveforms **H** and **I.** Actually this is the pulse delay circuit; the duration of this delay is adjustable by use of the TRIGGER RANGE and VERNIER controls. Waveform **I** is differentiated by C205 and R209 which yields waveform **J.**

The trigger position buffer amplifier (V202) amplifies only the positive portion of waveform **J.** The amplified output is an isolated low-impedance negative trigger source for subsequent stages.

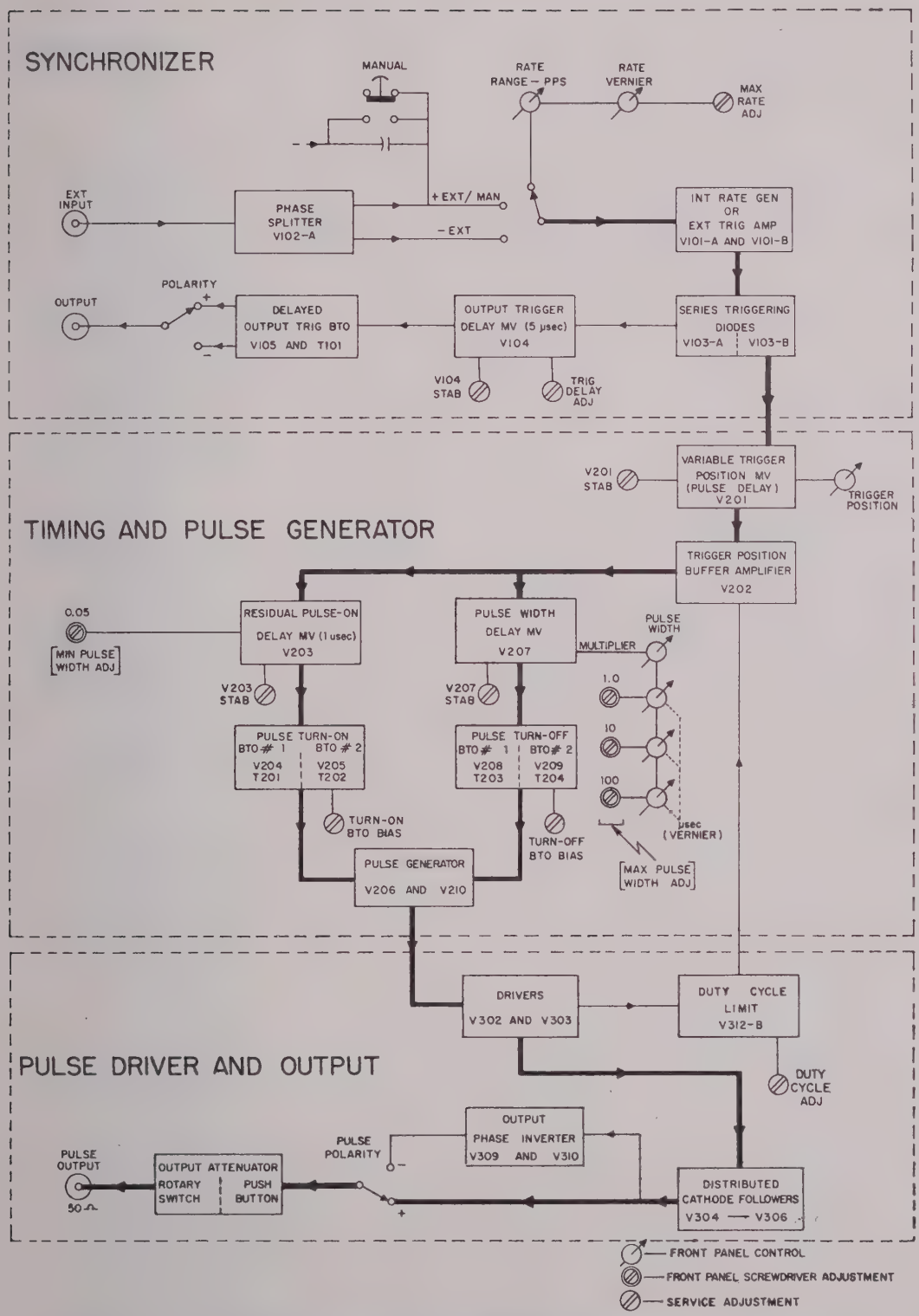


Figure 3-1. Over-all Functional Block Diagram, Du Mont Type 404/404-R Pulse Generator

b. Pulse Turn-On Circuit

Waveform **K** at the plate of V202 is used to simultaneously initiate the residual pulse-on multivibrator (V203) and the pulse width delay multivibrator (V207).

The residual pulse-on delay circuit was inserted to simplify setting the minimum pulse width to 0.05 microseconds. V203 generates waveforms **L** and **M** and the latter waveform is differentiated by C209 and R219 to obtain waveform **N.** The positive portion of waveform **N** is used to fire the pulse turn-on BTO #1 (V204 & T201), which in turn fires BTO #2 (V205 & T202). The purpose of the cascaded blocking oscillator stages is to create a very sharp, narrow trigger with which to turn on the normally nonconducting tube (V206) of the pulse generator. See waveform **O** through **T** inclusively.

c. Pulse Turn-Off Circuit

Some time after the pulse generator is turned on, the output from a similar pair of cascaded blocking oscillators (pulse turnoff BTO #1: V208 & T203; BTO #2: V209 & T204) are used to turn off the main pulse. The time of the turn off is determined by the trailing edge of the pulse width delay multivibrator (V207), whose duration is controlled from the front panel by the PULSE WIDTH MULTIPLIER and μSEC controls. See waveforms **J** through **Y** inclusively.

At this point, the action of the timing and initial pulse generation phases is complete with the net result consisting of a negative pulse with fast transitions, controllable duration and position. From this point on, the function of the remaining circuitry is to process the initial pulse by speeding up, clipping and impedance transformation.

3-4. PULSE DRIVER AND OUTPUT

a. Driver

The driver stage (V302 & V303) consists of a pair of power pentodes with the control grids clamped to zero bias. The screen grid voltage of this stage is derived from V301 and adjusted by R302 so the plates of V302 and V303 are drawing maximum allowable current.

When the negative pulse from the pulse generator (V206 & V210) appears at the control grids of V302 and V303, plate current is abruptly cut off resulting in a large positive pulse at the plates. See waveform **Z.**

The driver plate load consists of the input end of a lumped constant transmission line terminated in its characteristic impedance of 300 ohms. The line serves a dual function of 1) separating the input capacitance of the output stage from the driver plates, thereby preserving pulse rise time and 2) making possible the use of three low-cost tubes in parallel for the output stages.

b. Distributed Cathode Followers (see Figure 3-3)

Each of the grids of the distributed cathode followers (V304 to V306) is connected to a different point on the delay line, in sequence, and uniformly spaced, so that the signal at each grid arrives at a time slightly later than that of its predecessor. Correction for this time difference is made by lengths of coaxial cable. Operation of the circuit is as follows: Since the first tube (V304) on the delay line receives the signal first, it has the longest delay correction in its cathode. The second tube, V305, has only one-half the delay correction of V304, whereas V306 has no correction. Thus, when the three outputs meet at a common point, all three signals combine and are additive.

The parameters of each of the distributed cathode followers are adjusted for an average source impedance of 150 ohms so that the three cathodes in parallel result in the universally accepted 50-ohm source impedance.

Additional refinements for the preservation of pulse waveform are incorporated such as the limit resistor (R315, R318, & R323) in each distributed cathode-follower grid which enables a clipping action thereby serving to maintain a uniformly flat pulse top. Also, each screen grid is made to follow the cathode waveform by means of screen-to-cathode bypass capacitors (C306 to C308). By holding screen voltages constant with respect to the input signal, the Miller capacity is held to a minimum which further serves to reduce increases in rise time due to capacitive loading.

c. Output Phase Inverter

Provision for negative output pulses is made via an output phase inverter (V309 & V310) stage consisting of a pair of high perveance dual triodes in parallel, driven from the distributed cathode followers. Part of the phase inverter plate load consists of a pair of ordinary 6.3-volt pilot light bulbs (I301 and I303) which serve as non-linear plate loads. Their function is to provide an increase in plate load as average current increases at high repetition rates, thereby serving to maintain constant amplitude negative pulses. Since the phase inverter grids are driven hard into conduction, changes of bias would result due to charging of the input coupling capacitor (C316). This is prevented by means of the phase

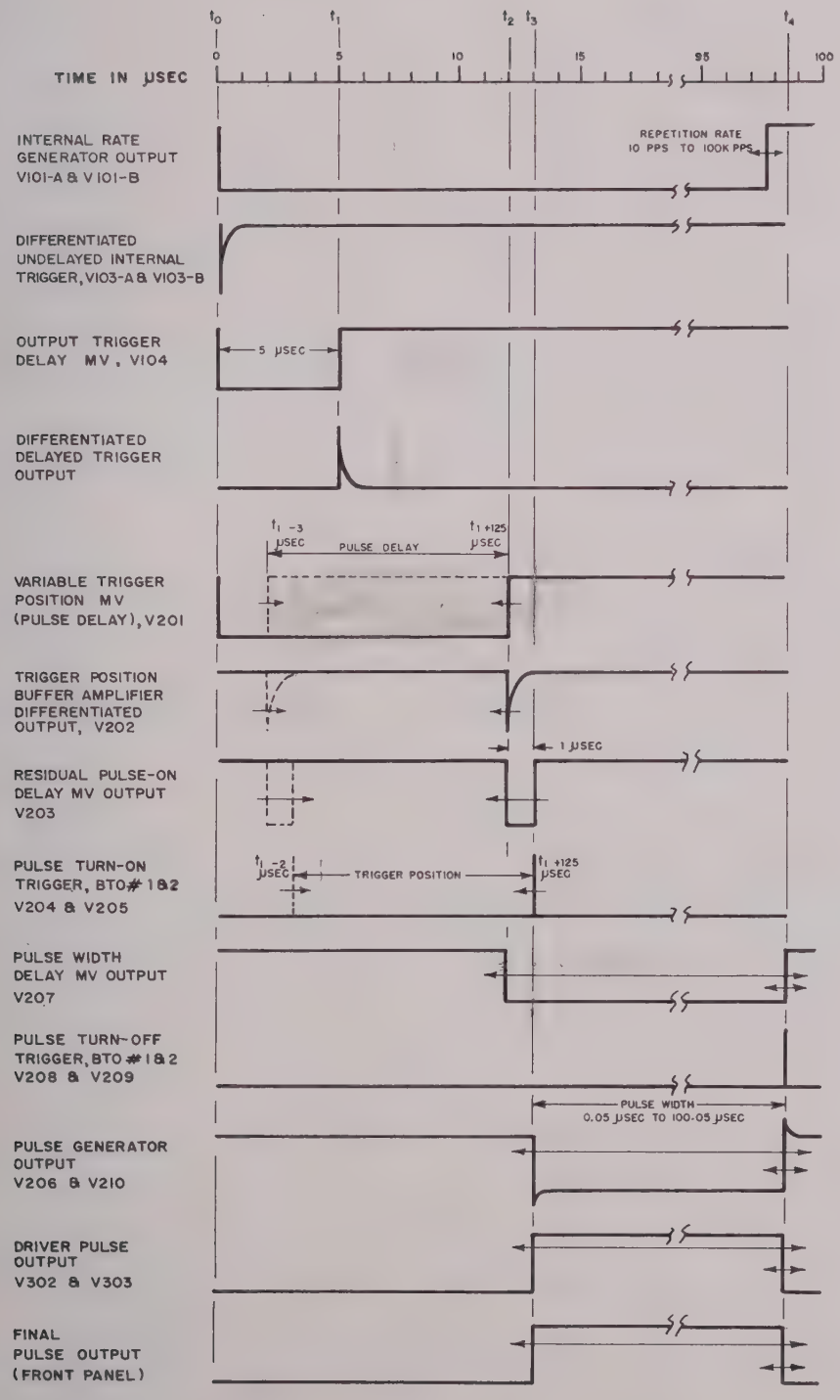

TIME IN μSEC
INTERNAL RATE GENERATOR OUTPUT V101-A & V101-B
REPETITION RATE 10 PPS TO 100K PPS
DIFFERENTIATED UNDELAYED INTERNAL TRIGGER, V103-A & V103-B
OUTPUT TRIGGER DELAY MV, V104
5 μSEC
DIFFERENTIATED DELAYED TRIGGER OUTPUT
PULSE DELAY
VARIABLE TRIGGER POSITION MV (PULSE DELAY), V201
TRIGGER POSITION BUFFER AMPLIFIER DIFFERENTIATED OUTPUT, V202
1 μSEC
RESIDUAL PULSE-ON DELAY MV OUTPUT V203
TRIGGER POSITION
PULSE TURN-ON TRIGGER, BTO # 1&2 V204 & V205
PULSE WIDTH DELAY MV OUTPUT V207
PULSE TURN-OFF TRIGGER, BTO # 1&2 V208 & V209
PULSE WIDTH 0.05 μSEC TO 100.05 μSEC
PULSE GENERATOR OUTPUT V206 & V210
DRIVER PULSE OUTPUT V302 & V303
FINAL PULSE OUTPUT (FRONT PANEL)

Figure 3-2. Type 404/404-R Pulse Generator Simplified Timing Diagram

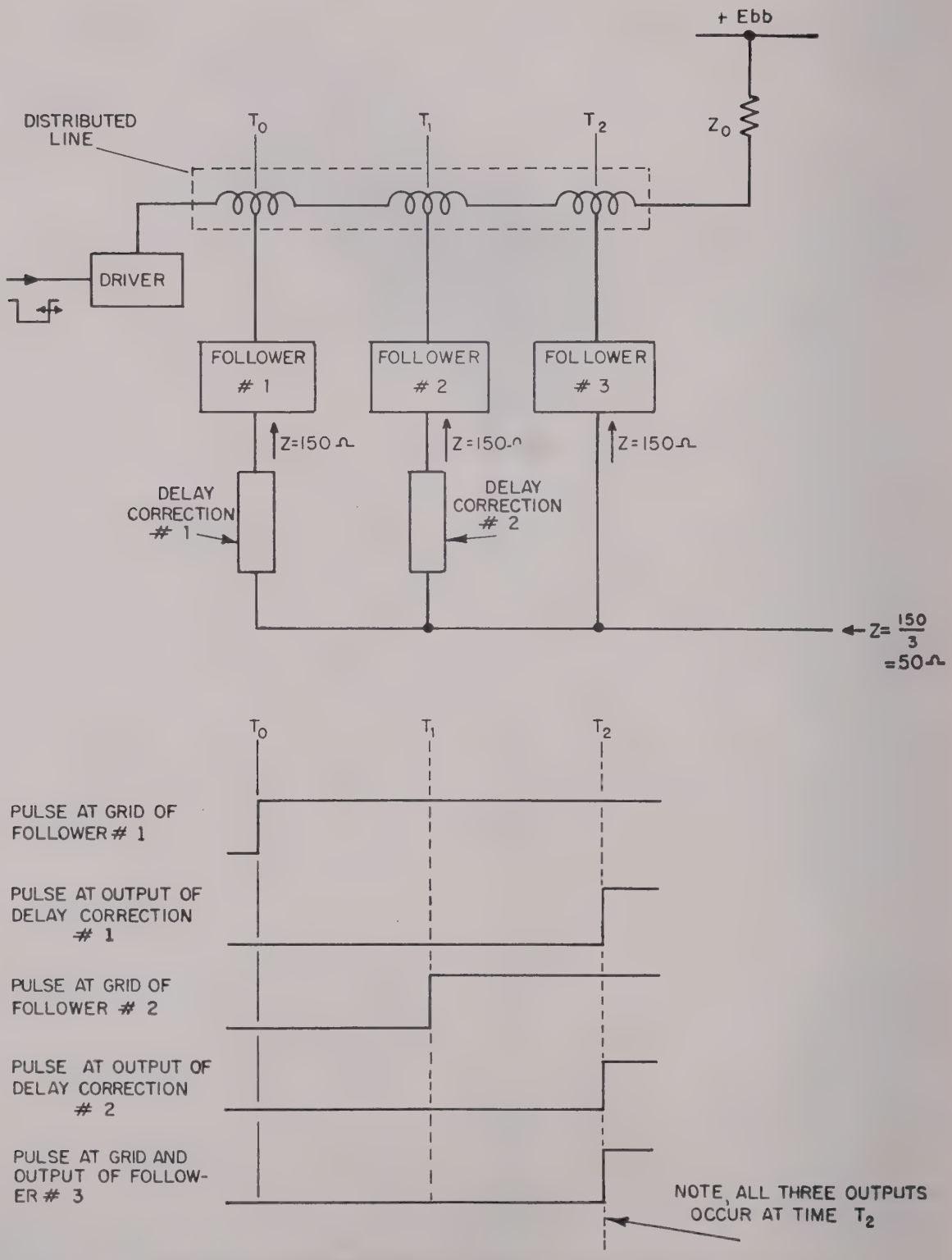


Figure 3-3. Distributed Cathode Followers, Simplified Schematic

inverter bias regulator (V311 & V312A) whose function is to maintain a constant, regulated bias source for V309 and V310.

d. Duty Cycle Limit

Some circuits in the Type 404 Pulse Generator operate with very high peak currents in the vicinity of two amperes. Consequently, it becomes necessary to limit the duty cycle to a point where the average power dissipation does not exceed safe tube and component rating. A positive safety feature has been incorporated to prevent operation beyond these ratings. This consists of an integrator circuit (C301 & R311) which compares pulse width to repetition rate. When the duty cycle reaches 10%, a relay (K301) is actuated which applies a negative voltage through the DUTY LIMIT indicator, I305, to the grid of the trigger position buffer amplifier, V202. This action intermittently turns V202 off and on. The operator is made physically aware of the danger point by an audible click and a warning light flash on the front panel (DUTY LIMIT). As soon as the pulses stop, the relay lets go allowing operation to resume. If nothing is done to lower the duty cycle, such as reducing pulse width or repetition rate, this process will continue at a rate determined by the amount that the duty cycle is being exceeded. In this way, the average power dissipation is automatically reduced to a safe value.

3-5. ATTENUATOR

A series of five 10 db attenuator steps are arranged in a ladder configuration so that only the first step requires high-wattage resistors; all of the other resistors used are standard one-half watt value. Six additional push button actuated attenuators provide sufficient small increments to enable a total attenuation range of 59.5 db in 0.5 db steps. The major advantage of this system is that a true impedance match exists under any possible combination of attenuator settings, thereby minimizing distortion of pulse waveforms.

3-6. POWER SUPPLY

a. +250 Supply Voltage

The +250-volt supply uses two selenium rectifiers (CR501 & CR502) connected in a conventional voltage doubling circuit. Capacitors C501 and C502 are charged on alternate half cycles and are connected in series, thus yielding an output voltage that is twice the peak voltage of the ac supply (about 100 volts). This voltage is added to the output from the +130-volt rectifier making a total of approximately 300 volts, which is then applied to a conventional voltage regulator yielding +250 volts output.

b. +130 Supply Voltage

The +130-volt supply uses two selenium rectifiers (CR503 & CR504) connected in a conventional full-wave rectifier circuit. The rectified output is capacitively filtered (C505 to C507) and is applied to a conventional voltage regulator which yields +130 volts output.

c. —150 Supply Voltage

The —150-volt supply uses two selenium rectifiers (CR505 & CR506) connected as a voltage doubler. This circuit produces a result equivalent to that of a conventional voltage-doubling circuit except that it has the advantage of a high-source impedance. The rectified output is regulated by a gas diode (V506).

The instrument is protected by a 6¼ ampere fuse, (F501) located in the primary circuit.

SECTION 4
MAINTENANCE

4-1. GENERAL

The Type 404 Pulse Generator is enclosed in a cabinet which is composed of two removable covers (top and bottom). To gain access to the chassis, loosen the screws on top and sides of the desired cover and slip it out of the slotted holes. To gain access to the Type 404-R chassis, remove the dust cover.

WARNING

OBSERVE THE FOLLOWING PRECAUTIONS WHEN NECESSARY TO ENERGIZE THE EQUIPMENT WITH THE CABINET REMOVED:

1) Never work alone.
2) Make sure the chassis is properly grounded.
3) Remove power cord before changing any tubes.
4) Before touching any components, short the terminals to remove any possible charge that may remain after turning off the power.

4-2. SERVICE ADJUSTMENTS

Do not touch any service adjustments unless tests clearly indicate the need to do so. Such adjustments should not be attempted without a complete understanding of the proper procedure. Consult Tables 4-1 and 4-2 for special instructions. The procedures given in Table 4-2 are based on the assumption that no tubes or components are faulty. Whenever these conditions are not met, see paragraph 4-3, Servicing Hints.

4-3. SERVICING HINTS

In the event of improper equipment performance, the following suggestions are recommended:

1) Note that all tube heaters are lit.
2) Check all supply voltages; including the ac power line, +250, +130, —150, and —7.5 volt levels.
3) *Do not tamper* with any of the service adjustments as this will only complicate servicing.
4) Localizing the trouble is made easier by use of a test probe coupled to a cathode-ray oscilloscope. The correct waveforms are shown on the schematics. Each waveform is identified by a code letter to show the exact point at which it occurs.
5) Avoid short-circuiting any components with the test probe.
6) When a point is reached where normal performance ceases abruptly, a replacement tube should be tried before attempting any other tests. In some cases, a second new tube must be tried.
7) As a further aid to servicing, refer to Table 4-4: Symptoms of Tube Failure Chart.
8) Replacement of certain tubes will require resetting of one or more service adjustments. Consult Table 4-3. For optimum stability, the new tube should be allowed a warm-up time of at least one hour before making any final service adjustments.
9) If after tube replacement the trouble persists, replace the original tube in its socket and check for proper voltage and resistance per Tables 4-5 and 4-6.
10) Maintain a high quality of workmanship. Use a clean bench and soldering iron; keep solder joints smooth and bright; do not overheat any component while soldering.

TABLE 4-1
TEST EQUIPMENT REQUIRED FOR SERVICE ADJUSTMENTS

REF. No.	DESCRIPTION	RANGE OR CHARACTERISTICS
(1)	Volt-ohmmeter	20K ohms volt Test Meter
(2)	Cathode-ray Oscilloscope	Du Mont Type 329-A Cathode-ray Oscilloscope or equivalent; supplied with appropriate test probes

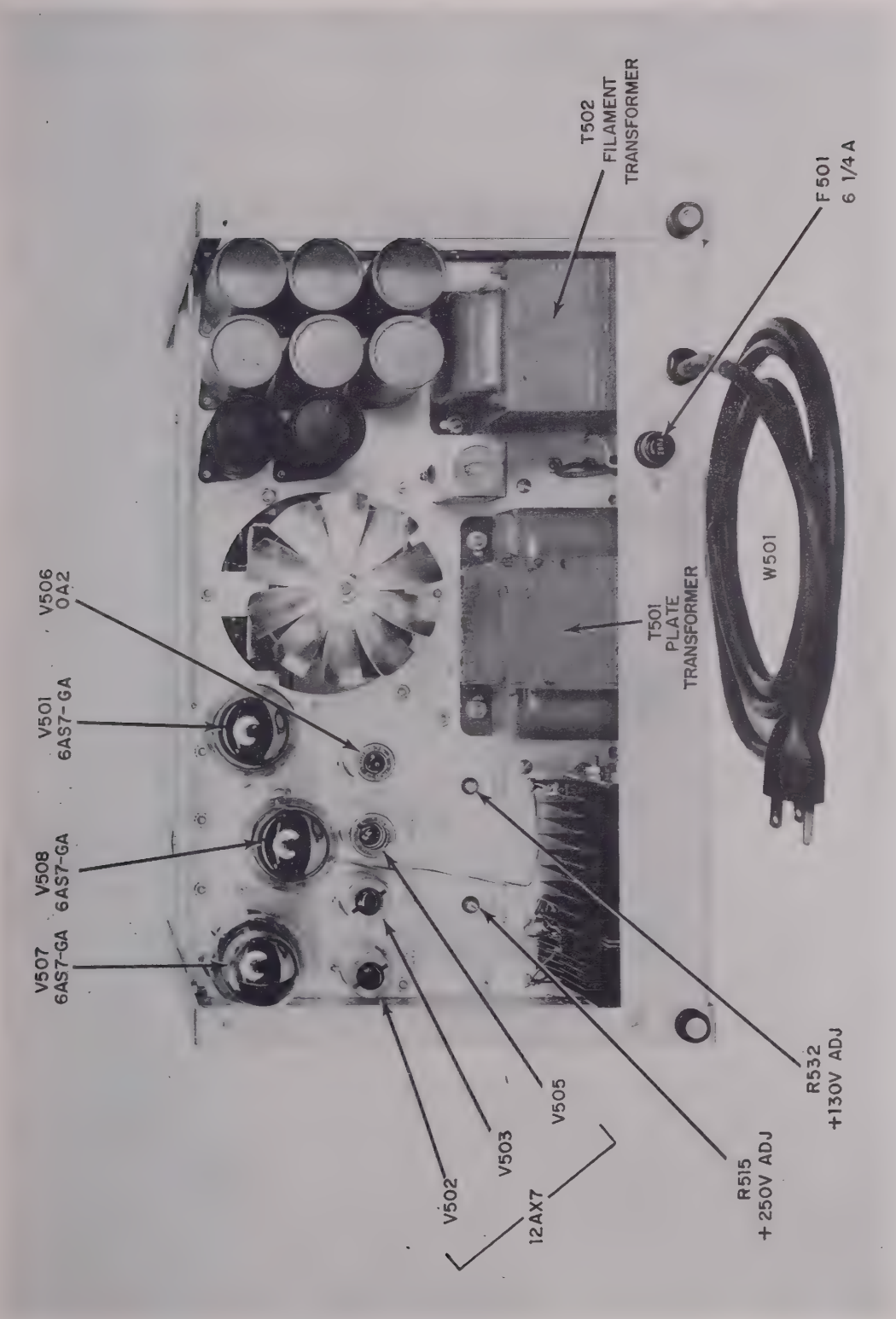


Figure 4-1. Tubes and Adjustments, Rear View

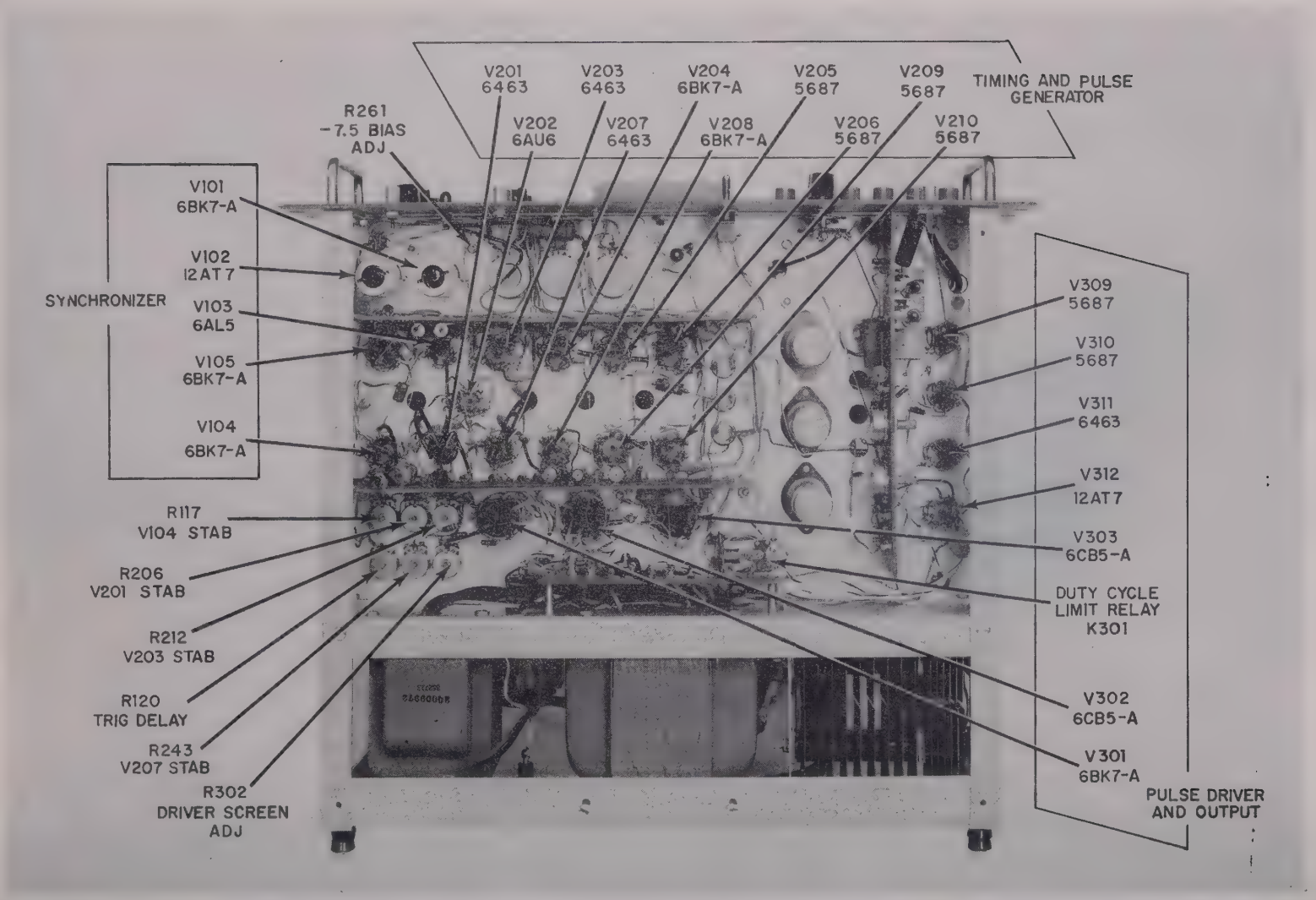


Figure 4-2. Tubes and Adjustments, Bottom View

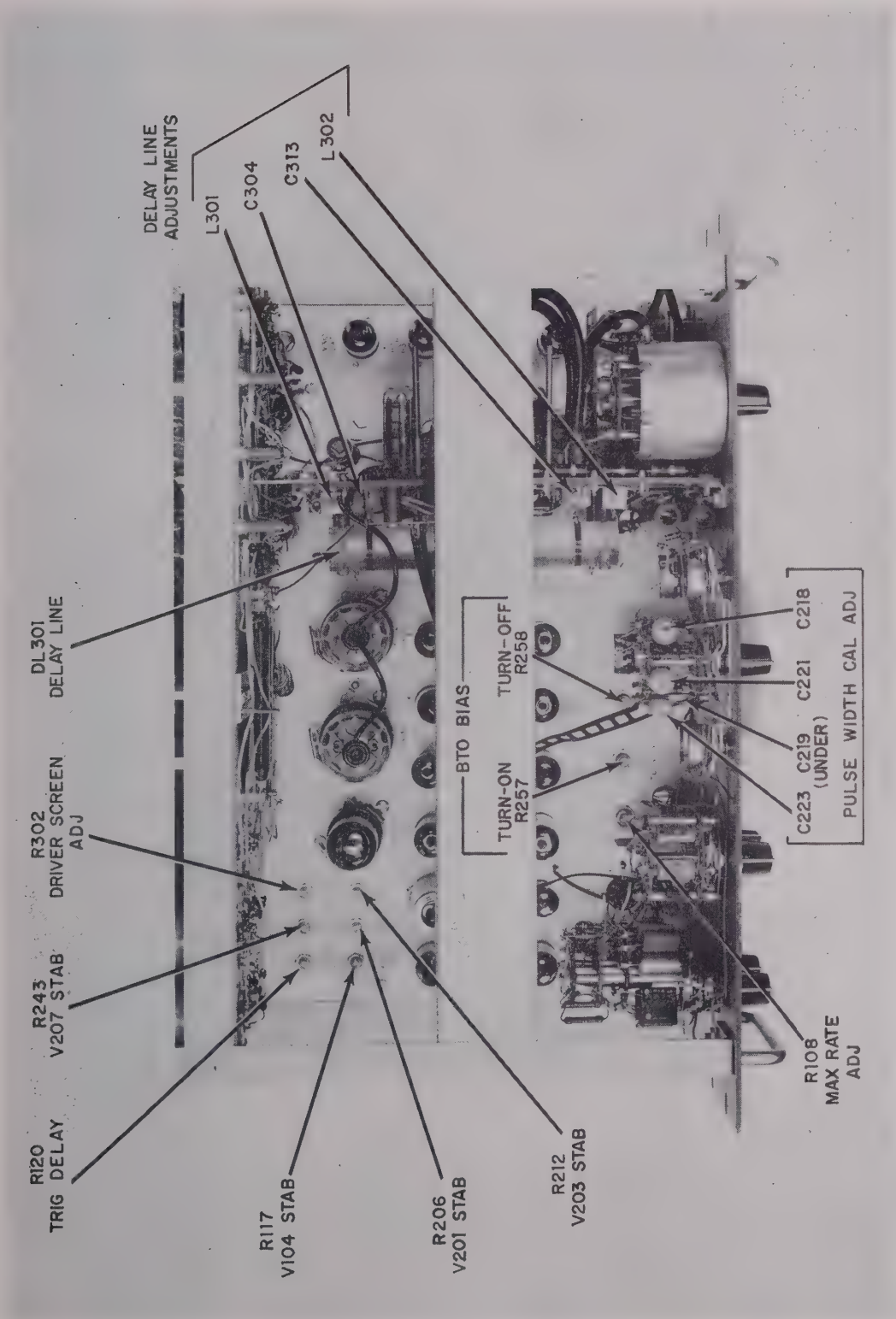


Figure 4-3. Adjustments, Top View

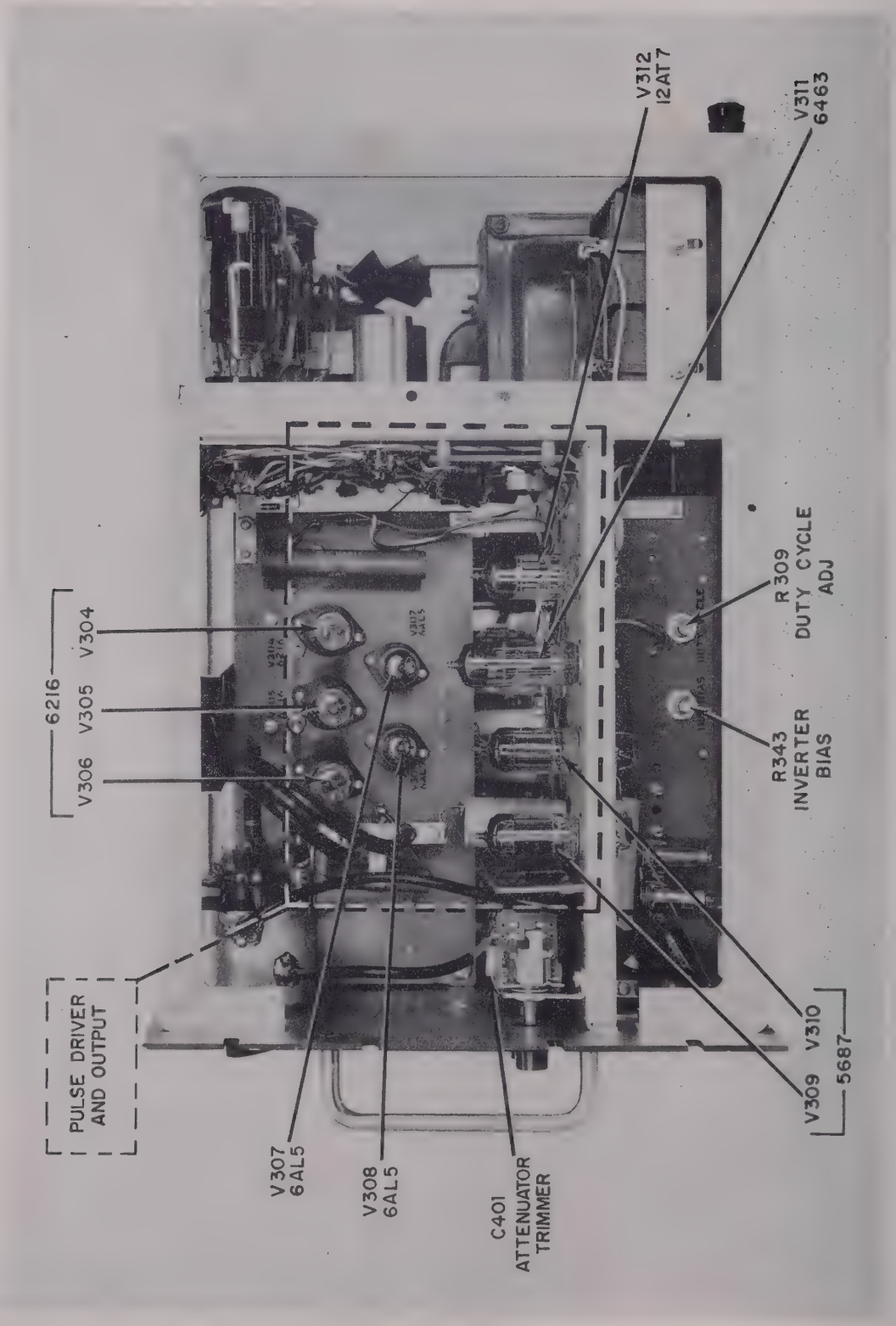


Figure 4-4. Tubes and Adjustments, Right Side

TABLE 4-2
SERVICE ADJUSTMENT CHART

PRECAUTION

DO NOT SET ANY SERVICE ADJUSTMENT WITHOUT FOLLOWING SPECIFIC INSTRUCTIONS AND SEQUENCE GIVEN IN TABLE 4-2. SOME ADJUSTMENTS ARE INTERDEPENDENT.

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
+250V ADJ (R515) Fig. 4-1	(1)	Connect a voltmeter from the insulated standoff next to V501 and ground. Adjust R515 for +250 volts
+130V ADJ (R532) Fig. 4-1	(1)	Connect a voltmeter from the insulated standoff next to V507 or V508 and ground. Adjust R532 for +130 volts
—7.5V ADJ (R261) Fig. 4-2	(1)	Connect a voltmeter from pin 8 of V102B (negative) and ground. Adjust R261 for —7.5 volts (equipment untriggered)
MAX RATE ADJ (R108) Fig. 4-3	(2)	R108 is used to set the maximum internal trigger repetition rate to 100,000 pps 1. Connect a properly terminated cable between trigger OUTPUT and the input of a cathode-ray oscilloscope 2. Set RATE RANGE—PPS to 100K, RATE VERNIER fully clockwise, and POLARITY to + 3. Adjust R108 for an interval of 10 μsec between triggers as viewed on the cathode-ray oscilloscope
V104 STAB (R117) Fig. 4-3	(2)	R117 is used to control the threshold bias of V104 1. Set TRIG DELAY ADJ (R120) fully clockwise 2. With an appropriate test probe connected to the input of a cathode-ray oscilloscope, check waveform **D** while turning R117 clockwise 3. Set R117 to slightly below the point where instability occurs
V201 STAB (R206) Fig. 4-3	(2)	R206 is used to control the threshold bias of V201 1. Set TRIGGER POSITION VERNIER fully clockwise 2. Check waveform **I** while turning R206 clockwise 3. Set R206 to slightly below the point where instability occurs
V203 STAB (R212) Fig. 4-3	(2)	R212 is used to control the threshold bias of V203 1. Set 0.05 μsec (minimum pulse width adjustment on front panel) fully counterclockwise 2. Check waveform **M** while turning R212 clockwise 3. Set R212 to slightly below the point where instability occurs
V207 STAB (R243) Fig. 4-3	(2)	R243 is used to control the threshold bias of V207 1. Set PULSE WIDTH MULTIPLIER to X10 and μSEC (vernier) fully clockwise 2. Check waveform **V** while turning R243 clockwise 3. Set R243 to slightly below the point where instability occurs
Delay Line Adjustments (C304, L301, C313, L302); DRIVER SCREEN ADJ (R302) TURN-ON BTO BIAS (R257) TURN-OFF BTO BIAS (R258) Fig. 4-3	(2)	These adjustments are used to control the shape of the positive pulse 1. Connect a properly terminated cable from the PULSE OUTPUT terminal directly to the vertical deflection plates of a cathode-ray oscilloscope

* Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-2. SERVICE ADJUSTMENT CHART (Continued)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
		2. Set PULSE POLARITY to +
		3. Adjust C304, L301, C313, L302, and R302 for the best possible pulse waveshape
		4. If necessary, adjust TURN-ON BTO BIAS to correct the leading edge of the pulse as the repetition rate is increased
		5. Similarly, an erratic pulse trailing edge is corrected by TURN-OFF BTO BIAS
		6. The adjustments in steps 4 and 5 should be set as near clockwise as possible
		7. It may be necessary to go back and forth several times, resetting each of the above adjustments until the best possible compromise in waveshape is reached
INVERTER BIAS (R343) Fig. 4-4	(2)	R343 is used to control the shape of the negative pulse: it is adjusted after the first three steps above are completed
		1. Set PULSE POLARITY to —
		2. Adjust R343 for the best possible negative pulse
Attenuator Trimmer (C401) Fig. 4-4	(2)	C401 is used to preserve pulse waveshape
		Adjust C401 for sharpness at beginning of pulse flat top with minimum possible ringing or overshoot
TRIG DELAY ADJ (R120) Fig. 4-3	(2)	R120 enables setting of pulse advance to 2 μsec (with respect to the internal delayed trigger OUTPUT)
		1. Connect a properly terminated cable between trigger OUTPUT and the external sync terminal of a cathode-ray oscilloscope; and between PULSE OUTPUT and the vertical input of the cathode-ray oscilloscope
		2. Set PULSE WIDTH MULTIPLIER and μSEC controls for a 2 μsec pulse
		3. Set POSITION VERNIER fully counterclockwise and POSITION RANGE to 5
		4. Adjust R210 so that the trailing edge of the pulse is just barely visible at left edge of screen
DUTY CYCLE ADJ (R309) Fig. 4-4	—	R309 is used to set the maximum duty cycle of the instrument to 10%
		1. Set RATE RANGE—PPS to 100K, PULSE WIDTH MULTIPLIER and μSEC for a 1 μsec pulse
		2. Starting from the fully clockwise position, set R309 to the point where the duty cycle limit relay (K301) begins to click and the DUTY LIMIT indicator flashes
		3. Increasing the pulse width should increase relay clicking; decreasing pulse to less than 1 μsec should cause relay to stop clicking
Pulse Width Calibration Adjustments: C223 Fig. 4-3	(2)	C223 is used for calibrating the low end of the 1 μsec pulse range
		1. Set μSEC to 1, PULSE WIDTH MULTIPLIER to X0.1, and turn the 0.05 front-panel screwdriver control to center of range
		2. Adjust C223 to obtain a pulse width of 0.1 μsec as viewed on a cathode-ray oscilloscope. This is a preliminary coarse adjustment
		3. Final vernier adjustment is made by the 0.05 control to give a pulse width of exactly 0.1 μsec
C221 Fig. 4-3	(2)	C221 is used for calibrating the low end of the 10 μsec pulse range
		1. Set PULSE WIDTH MULTIPLIER to X1
		2. Set C221 to obtain a pulse width of exactly 1 μsec

* Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-2. SERVICE ADJUSTMENT CHART (Continued)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
C218 & C219 Fig. 4-3	(2)	C218 and C219 are used for calibrating the low end of the 100 μsec pulse range 1. Set PULSE WIDTH MULTIPLIER to X10 2. Set C218 and/or C219 to give a pulse width of exactly 10 μsec
1.0, 10, & 100 μsec	(2)	These front-panel screwdriver controls are used to calibrate the high end of their respective pulse ranges 1. Set μSEC dial to 10 2. Set PULSE WIDTH MULTIPLIER to X0.1; adjust the "1" control to obtain a pulse width of 1 microsecond 3. Set PULSE WIDTH MULTIPLIER to X1; adjust the "10" control to obtain a pulse width of 10 microseconds 4. Set PULSE WIDTH MULTIPLIER to X10; adjust the "100" control to obtain a pulse width of 100 microseconds

* Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-3
ADJUSTMENTS TO BE MADE WHEN REPLACING TUBES

SYMBOL	TYPE	SERVICE ADJUSTMENTS TO BE CHECKED (See Table 4-2)
SYNCHRONIZER		
V101	6BK7-A	MAX RATE ADJ (R108)
V102	12AT7	—7.5V BIAS ADJ (R261)
V103	6AL5	None
V104	6BK7-A	V104 STAB (R117) and TRIG DELAY ADJ (R120)
V105	6BK7-A	None
TIMING AND PULSE GENERATOR		
V201	6463	V201 STAB (R206)
V202	6AU6	None
V203	6463	V203 STAB (R212) and 0.05 μsec (R214)
V204	6BK7-A	None
V205	5687	TURN-ON BTO BIAS (R257)
V206	5687	None
V207	6463	V207 STAB (R243); all pulse width calibration adjustments, includes: 1, 10, and 100 μsec (front panel); C218, C219, C221 and C223
V208	6BK7-A	None
V209	5687	TURN-OFF BTO BIAS (R258)
V210	5687	None
PULSE DRIVER AND OUTPUT		
V301	6BX7-GT	DRIVER SCREEN ADJ (R302)
V302 & V303	6CB5-A	Delay Line Adjustments (L301, L302, C304, and C313)
V304 to V306	6216	Delay Line Adjustments (L301, L302, C304, and C313)
V307 & V308	6AL5	None
V309 & V310	5687	INVERTER BIAS (R343)
V311 & V312	6463 & 12AT7	INVERTER BIAS (R343)
POWER SUPPLY		
V501	6AS7-GA	+250V ADJ (R515)
V502	12AX7	+250V ADJ (R515)
V503	12AX7	+250V ADJ (R515) and +130V ADJ (R532)
V505	12AX7	+130V ADJ (R532)
V506	OA2	None
V507 & V508	6AS7-GA	+130V ADJ (R532)

TABLE 4-4
SYMPTOMS OF TUBE FAILURE CHART

NOTES: 1. Some of the symptoms indicated in this table might be caused by the misalignment of service adjustments or failure of some component associated with the circuit under analysis.

2. The waveforms mentioned in the table are shown on the schematics. Each waveform is identified by a code letter to show the exact point at which it occurs.

TUBE SYMBOL	SYMPTOMS OF TUBE FAILURE
SYNCHRONIZER	
V101	a. No OUTPUT triggers b. No response to triggers applied to EXT INPUT c. No waveform at **A**
V102A V102B	a. Equipment operation is normal except there is no response to triggers applied to EXT INPUT b. The —7.5 BIAS ADJ (R261) is improperly set; see Table 4-2. If this bias level is set too high, the BTO stages (V204 and V208) will be inoperative
V103A V103B	a. No OUTPUT triggers b. Satisfactory waveform at **B**, nothing at **C**; hence the output trigger delay multivibrator (V104) is not receiving the initiating trigger c. No PULSE OUTPUT d. Satisfactory waveform at **B**, nothing at **H**; hence the variable trigger position multivibrator (V201) is not receiving the initiating trigger
V104	a. No OUTPUT triggers b. Satisfactory waveform at **B**; improper or no waveform at **C** and/or **D**
V105	a. No OUTPUT triggers b. Satisfactory waveform at **D** and **E**; none at **F** or **G**
TIMING AND PULSE GENERATOR	
V201	a. No PULSE OUTPUT b. OUTPUT triggers are satisfactory; see waveform **G** c. No waveform at **J** input to trigger position buffer amplifier (V202) d. Intermittent performance of MANUAL triggering system can also be traced to either V201 or improper adjustment of V201 STAB (R206)
V202	a. No PULSE OUTPUT b. Satisfactory waveform at the control grid **J**; nothing at the plate **H**
V203 to V205	a. No PULSE OUTPUT b. Loss of PULSE OUTPUT at high repetition rates
V206	a. No PULSE OUTPUT b. Poor pulse waveform NOTE: This tube is the normally-off half of the multivibrator. Under no circumstances should the instrument be allowed to remain in operation, if the normally-on half (V210) of the multivibrator is removed from its socket or is known to be defective.
V207 to V209	a. Pulse width approximately 150 μsec b. PULSE WIDTH MULTIPLIER control is inoperative
V210	a. No PULSE OUTPUT b. Poor pulse waveform c. Cannot adjust the instrument for a minimum pulse width of 0.05 microsecond d. Check waveforms **L** through **Y** inclusively

TABLE 4-4
SYMPTOMS OF TUBE FAILURE CHART (Continued)

TUBE SYMBOL	SYMPTOMS OF TUBE FAILURE
PULSE DRIVER AND OUTPUT	
V301	a. No PULSE OUTPUT b. Continuous operation of duty cycle relay (K301)
V302 & V303	a. No PULSE OUTPUT b. Continuous operation of duty cycle relay (K301) c. Unsatisfactory waveform at plates of V302 and V303 **Z**
V304 to V306	a. Unsatisfactory PULSE OUTPUT waveform b. Insufficient pulse amplitude
V307 & V308	a. Unsatisfactory PULSE OUTPUT waveform
V309 & V310	a. Positive PULSE OUTPUT is satisfactory b. Unsatisfactory negative PULSE OUTPUT waveform
V311	a. Unsatisfactory negative PULSE OUTPUT b. Insufficient pulse amplitude c. Amplitude of negative pulse is over-sensitive to variations in the repetition rate
V312A	a. Unsatisfactory negative PULSE OUTPUT b. I301 through I304 are brilliantly lit NOTE: This instrument should not be allowed to remain in operation when V312 is removed from its socket or is known to be defective
V312B	c. Defective performance of duty cycle limit circuit
POWER SUPPLY AND HEATER CIRCUITS	
V501 & V502	a. +250 supply voltage is too low; poor regulation b. +130 supply voltage is also affected c. Excessive ripple or oscillations
V503A & V503B	a. +250 supply voltage is too high; poor regulation b. +130 supply voltage is too high; poor regulation c. Excessive ripple or oscillations
V505, V507 & V508	a. +130 supply voltage is too low; poor regulation b. +250 supply voltage is normal c. Excessive ripple or oscillations
V506	a. —150 supply voltage is too high b. Excessive ripple or oscillations in —150-volt supply c. Both the +250 and —130 supply voltages are too high NOTE: The instrument should not be allowed to operate under these conditions
CR501 & CR502	a. Same as V501
CR 503 & CR504	a. Same as V507 or V508
CR505 & CR506	a. V506 does not glow b. —150 supply voltage is too low c. +250 and +130 supply voltages are too low

TABLE 4-5
VOLTAGE MEASUREMENTS

NOTES: 1. All voltages measured with a 20K-ohm/ voltmeter; measurements taken from tube socket to chassis
2. All voltages are dc and positive with respect to chassis, except where otherwise indicated
3. All measurements taken with RANGE RATE-PPS set to +EXT/MAN
4. *Indicates measurement with VTVM

SYMBOL	TYPE	1	2	3	4	5	6	7	8	9
					SYNCHRONIZER					
	NOTES: 5. Tube socket voltage variation is indicated as follows: a) Varies with V104 STAB (R117)									
V101	6BK7-A	50	0.5	0	0	6.3ac	128	—7	0	0
V102	12AT7	125	*4.5	5	0	0	130	—8.5	—7.5	6.3ac
V103	6AL5	130	130	0	6.3ac	130	0	130	.....	
V104	6BK7-A	130	a) 52	57	0	6.3ac	130	57	57	0
V105	6BK7-A	250	—7.5	2.5	0	6.3ac	250	—7.5	0	0
					TIMING AND PULSE GENERATOR					
	NOTES: 6. Tube socket voltage variations are indicated as follows: a) Varies approximately 10 volts over range of TRIGGER POSITION VERNIER control; b) Varies with V201 STAB (R206); c) Varies with 0.05 μsec (min pulse width adj) on front panel; d) Varies with V203 STAB (R212); e) Varies with TURN-ON BTO BIAS (R257); f) Varies with μSEC (Pulse Width Vernier) control; g) Varies with V207 STAB (R243); h) Varies with TURN-OFF BTO BIAS (R258)									
V201	6463	110	a) 37	a) 37	0	0	130	a) 37	b) 18	6.3ac
V202	6AU6	—7.5	0	0	6.3ac	130	130	0	. .	..
V203	6463	110	c) 37	c) 37	0	0	130	c) 37	d) 18	6.3ac
V204	6BK7-A	250	—7.5	0	0	6.3ac	250	—7.5	0.5	0
V205	5687	250	e) —90	—45	0	0	12	—7.5	6.3ac	250
V206	5687	130	—45	0	0	0	0	—45	6.3ac	130
V207	6463	110	f) 37	f) 37	0	0	130	f) 37	g) 18	6.3ac
V208	6BK7-A	250	—7.5	0.1	0	6.3ac	250	—7.5	0	0
V209	5687	250	—7.5	12	0	0	2	h) —60	6.3ac	250
V210	5687	60	2	0	0	0	0	2	6.3ac	60

TABLE 4-5. VOLTAGE MEASUREMENTS (Continued)

SYMBOL	TYPE	1	2	3	4	5	6	7	8	9
		PULSE DRIVER AND OUTPUT								
	NOTES: 6. Tube socket voltage variations are indicated as follows: a) Varies with DRIVER SCREEN ADJ (R302) b) Indicates plate cap reading—not pin 9 c) Varies with INVERTER BIAS (R343) d) Varies with DUTY CYCLE ADJ (R309) and with duty cycle while operating									
V301	6BX7-GT	a) 65	130	a) 70	a) 65	130	a) 70	0	6.3ac	. .
V302	6CB5	a) 70	0	0	0.75	0.75	0	6.3ac	a) 70	a, b) 45
V303	6CB5	a) 70	0	0	0.75	0.75	0	6.3ac	a) 70	a, b) 45
V304	6216	250	a) 45	a) 65	0	6.3ac	250	250	a) 65	
V305	6216	250	a) 45	a) 65	0	6.3ac	250	250	a) 65	. ...
V306	6216	250	a) 45	a) 65	0	6.3ac	250	250	a) 65	.
V307	6AL5	.....	250	0	6.3ac	250	0	..	. .	
V308	6AL5	250	250	0	6.3ac	250	0	250		. .
V309	5687	130	c) —10	0	0	0	0	c) —10	6.3ac	130
V310	5687	130	c) —10	0	0	0	0	c) —10	6.3ac	130
V311	6463	130	c) —10	c) —22*	0	0	130	c) —10	c) —22*	6.3ac
V312	12AT7	c) 22	c) 0.1	0	0	0	250	d) 10	d) 13	6.3ac
		POWER SUPPLY								
V501	6AS7-GA	230	340	250	230	340	250	0	6.3ac	...
V502	12AX7	80	0	1	0	0	*155	*—0.6	1	6.3ac
V503	12AX7	230	—3	0	0	0	120	—1.5	0	6.3ac
V505	12AX7	80	0	1	0	0	*155	*—0.6	1	6.3ac
V506	0A2	0	—150	.....	—150	0	.....	—150		. ...
V507	6AS7-GA	120	210	134	120	210	134	0	6.3ac	. .
V508	6AS7-GA	120	210	134	120	210	134	0	6.3ac	.....

TABLE 4-6
RESISTANCE MEASUREMENTS

NOTES: 1. All resistance measurements taken from tube socket to chassis
2. All resistance measurements are in ohms; K=thousand, M=million
3. Do not take readings immediately after turning off equipment

SYMBOL	TYPE	1	2	3	4	5	6	7	8	9
				SYNCHRONIZER						
		NOTES: 3. Tube socket resistance variations are indicated as follows: a) Varies with RATE VERNIER control setting b) Depends on meter polarity c) Varies with V104 STAB (R117) d) Varies with TRIG DELAY ADJ (R120)								
V101	6BK7-A	16K	a) 200K-2M	0	0.5	0.5	16K	a) 200K-2M	0	0
V102	12AT7	40K	390K	1K	0	0	4K	12K	13.K	0.5
V103	6AL5	b) 4K/20K	10K	0	0.5	b) 4K/20K	0	10K		
V104	6BK7-A	10K	c) 22K-32K	5.6K	0	0.5	4K	d) 2M-4.5M	5.6K	0
V105	6BK7-A	15K	1.5K	470	0	0.5	15K	3.5K	0	0
				TIMING AND PULSE GENERATOR						
		NOTES: 4. Tube socket resistance variations are indicated as follows: a) Varies with TRIGGER POSITION VERNIER control setting b) Varies with V201 STAB (R206) c) Varies with 0.05 μsec (min pulse width adj) on front panel d) Depends on meter polarity e) Varies with V203 STAB (R212) f) Varies with PULSE WIDTH MULTIPLIER and μsec (Vernier) control settings g) Varies with V207 STAB (R243) h) Varies with TURN-OFF BTO BIAS (R258)									
V201	6463	5K	1.5K	a) 120K-600K	0	0	10K	1.6K	b) 0-250K	0.5
V202	6AU6	3.5K	0	0	0.5	4K	4K	0	.....	.....
V203	6463	5K	1.5K	c) 150K-200K	0	0	d) 4K/10K	1.6K	e) 0-25K	0.5
V204	6BK7-A	15K	3.5K	0	0	0.5	15K	1.3K	390	0
V205	5687	15K	7K	20K	0	0	1K	1.3K	0.5	15K
V206	5687	4.3K	20K	0	0	0	0	20K	0.5	4.3K
V207	6463	5K	1.5K	f) 150K-5M	0	0	d) 4K/10K	1.6K	g) 0-25K	0.5
V208	6BK7-A	15K	1.3K	47	0	0.5	15K	3.5K	0	0
V209	5687	15K	1.3K	1K	0	0	60K	h) 1.5K-7.5K	0.5	15K
V210	5687	15K	60K	0	0	0	0	60K	0.5	15K

TABLE 4-6. RESISTANCE MEASUREMENTS (Continued)

SYMBOL	TYPE	1	2	3	4	5	6	7	8	9
					PULSE DRIVER AND OUTPUT					
		NOTES: 5. Tube socket resistance variations are indicated as follows: a) Indicates plate cap reading—not pin 9 b) Varies with DUTY CYCLE ADJ (R309)								
V301	6BK7-GT	18K	4K	Inf	18K	4K	Inf	0	0.5	
V302	6CB5	Inf	0	0	50K	50K	0	0.5	Inf	a) 4.3K
V303	6CB5	Inf	0	0	50K	50K	0	0.5	Inf	a) 4.3K
V304	6216	15K	4.5K	750	0	0.5	15K	Inf	750	
V305	6216	15K	4.5K	750	0	0.5	15K	Inf	750	.....
V306	6216	15K	4.5K	750	0	0.5	15K	Inf	750	.....
V307	6AL5	.....	15K	0	0.5	Inf	0	.....	.....	.....
V308	6AL5	Inf	15K	0	0.5	Inf	0	15K	.....	.....
V309	5687	4K	80K	0	0	0	0	80K	0.5	4K
V310	5687	4K	80K	0	0	0	0	80K	0.5	4K
V311	6463	4K	80K	60K	0	0	4K	80K	60K	0.5
V312	12AT7	45K	50K	0	0	0	15K	1M	b) 1K-3.5K	0.5
					POWER SUPPLY					
V501	6AS7-GA	1M	20K	15K	1M	20K	15K	0	0.5	.....
V502	12AX7	800K	0	400K	0	0	400K	200K	400 K	0.5
V503	12AX7	1M	1M	0	0	0	480 K	1M	0	0.5
V505	12AX7	800K	0	400K	0	0	400K	200K	400K	0.5
V506	OA2	0	10K	.....	10K	0	.....	10K	.....	.....
V507	6AS7-GA	471K	20K	4K	471K	20K	4K	0	0.5	.....
V508	6AS7-GA	471K	20K	4K	471K	20K	4K	0	0.5	.....

SECTION 5
ELECTRICAL PARTS LIST AND SCHEMATICS

Symbol	Part Number	Description
	BLOWER	
B501	8100 4251	motor
—	8100 3600	blade
	CAPACITORS	
	(all capacitors are fixed, ceramic, 500 V unless otherwise specified)	
C101 to C104	0312 2430	0.02 µf, +100 —0%
C105	0316 2550	paper, 0.25 µf, ±10%, 400 V
C106	0305 5130	mica, 68 µµf, ±5%
C107	0302 9200	mica, 680 µµf, ±5%
C108	0302 9550	mica, 6800 µµf, ±10%, 300 V
C109	0317 7610	paper, 0.068 µf, ±5%, 200 V
C111	0317 7610	paper, 0.068 µf, ±5%, 200V
C112	0302 9550	mica, 6800 µµf, ±10%, 300 V
C113	0302 9200	mica, 680 µµf, ±5%
C114	0305 5130	mica, 68 µµf, ±5%
C115	0315 2010	150 µµf, ±20%
C116	0313 1040	paper, 0.5 µf, ±20%, 200V
C117	0305 5360	mica, 15 µµf, ±5%
C118	0316 2550	paper, 0.25 µf, ±10%, 400 V
C119	0315 2010	150 µµf, ±20%
C122	0312 2430	0.02 µf, +100 —0%
C123	0313 1040	paper, 0.5 µf, ±20%, 200 V
C124	0312 2430	0.02 µf, +100 —0%
C201	0313 1040	paper, 0.5 µf, ±20%, 200 V
C202	0305 5130	mica, 68 µµf, ±5%
C203 & C204	0315 6600	470 µµf, ±20%, 1000 V
C205	0315 2010	150 µµf, ±20%
C206	0315 6600	470 µµf, ±20%, 1000 V
C207	0305 5010	mica, 22 µµf ±5%
C208	0315 6600	470 µµf, ±20%, 1000 V
C209	0315 2010	150 µµf, ±20%
C210	0302 1060	mica, 240 µµf, ±5%
C211	0315 2010	150 µµf, ±20%
C212	0312 2430	0.02 µf, +100 —0%
C213	0313 1040	paper, 0.5 µf, ±20%, 200 V
C214 & C215	0312 2430	0.02 µf, +100 —0%
C216	0305 5540	mica, 27 µµf, ±10%
C217	0316 2550	paper, 0.25 µf, ±10%, 400 V
C218 & C219	0315 0530	variable, 8-50 µµf, 350 V
C220	0302 0570	mica, 910 µµf, ±5%
C221	0315 0530	variable, 8-50 µµf, 350 V
C222	0305 5620	mica, 56 µµf, ±10%
C223	0315 0530	variable, 8-50 µµf, 350 V
C225 & C226	0315 6600	470 µµf, ±20%, 1000 V
C227	0315 2010	150 µµf, ±20%
C228	0313 1020	paper, 0.1 µf, ±20%, 200 V
C229	0312 2430	0.02 µf, +100 —0%
C231	0313 1040	paper, 0.5 µf, ±20%, 200 V
C232	0312 2430	0.02 µf, +100 —0%
C301	0312 2430	0.02 µf, +100 —0%
C302	0301 9510	paper, 0.04 µf, ±20%, 200 V
C304	0300 3070	variable, 4-30 µµf
C305	0312 2430	0.02 µf, +100 —0%
C306 to C308	0313 1020	paper, 0.01 µf, ±20%, 200 V
C309	0319 0071	electrolytic, 50 µf, 300 V
C311	0312 2430	0.02 µf, +100 —0%
C312	0319 0071	electrolytic, 50 µf, 300 V
C313	0300 3070	variable, 4-30 µµf
C314	0319 0071	electrolytic, 50 µf, 300 V
C315	0313 1040	paper, 0.5 µf, ±20%, 200 V
C316	0319 0061	electrolytic, 100 µf, 150 V
C317	0317 6050	electrolytic, 4 µf, 150 V
C318	0319 0061	electrolytic, 100 µf, 150 V
C401	0315 0530	variable, 8-50 µµf, 350 V
C501 & C502	0317 5860	electrolytic, 300 µf, 150 V
C503	0312 7620	paper, 0.1 µf, ±20%, 400 V
C504 to C507	0301 4460	electrolytic, 125 µf, +50 —10%, 350 V
C508	0312 7620	paper, 0.1 µf, ±20%, 400 V
C509	0311 6350	paper, 2 µf, ±5%, 600 V
C511 & C512	0301 4460	electrolytic, 125 µf, +50 —10%, 350 V
C513 to C515	0312 2430	0.02 µf, +100 —0%
	CRYSTALS	
CR101 & CR102	2600 1530	1N34A
CR201	2600 1530	1N34A
CR202	2600 0940	1N54A
CR203	2600 5170	1N307
CR204	2600 0940	1N44A
CR205	2600 5170	1N307
	RECTIFIERS	
	(metallic)	
CR501 & CR502	2600 2080	selenium, 400 ma
CR503 & CR504	2600 2110	selenium, plug-in type, 600 ma
CR505 & CR506	2600 5000	selenium, 50 ma
	DISTRIBUTED LINE	
DL301	8800 1451	delay line
	FUSE	
F501	1100 5250	6¼ ampere, slow blow
	LAMPS	
I301 & I303	1200 0840	incandescent, miniature bayonet, 0.250 ampere
I305	1200 0040	neon indicator
I501	1200 1370	incandescent, miniature bayonet, 0.250 ampere
	RELAY	
K301	0500 9740	armature, DPDT
	INDUCTORS	
L201	2101 3080	fixed, rf, 220 µh, ±10%
L301 & L302	2101 5482	variable, 1.3-2.6 µh

section 5
parts list and schematics

RESISTORS

(all resistors are in ohms, fixed, composition, ±10%, ½ W unless otherwise specified)

Symbol	Part Number	Description
R101	0225 1290	2.4M, ±5%
R102	0225 2080	390K
R103 & R104	0225 0680	6800 ±5%
R105	0225 2060	270K
R106	0225 2100	560K
R107	0203 3740	12K, ±5%, 1 W
R108	0101 4850	variable, 25K, ±20%, 2 W
R109 A, B	0107 1271	variable, 2.5M, ±20%, ¼ W
R111 & R112	0223 7290	film, 200K, ±1%
R113	0225 1920	18K
R114	0203 3740	12K, ±5%, 1 W
R115	0225 1920	18K
R116	0225 1950	33K
R117	0107 1023	variable, 10K, ±20%
R118	0225 1930	22K
R119	0225 1870	6.8K
R120	0107 1039	variable, 2.5M, ±25%
R121	0223 7650	film, 2M, ±1%
R122	0230 4580	wire wound, inductive, 5.6K, ±5%, 3 W
R123	0225 1810	2.2K
R124	0225 0230	91, ±5%
R125	0225 1730	470
R126	0225 1850	4700
R127	0225 1890	10K
R128 & R129	0225 0230	470
R201, A, B	0107 0422	variable, 100K/1M, ±20%
R202	0225 1870	6.8K
R203	0223 7230	film, 120K, ±1%
R204	0230 4490	wire wound, inductive, 1K, ±5%, 3 W
R205	0225 1960	39K
R206	0107 1024	variable, 25K, ±20%
R207	0225 1650	100
R208	0230 4510	wire wound, inductive, 1.5K, ±5%, 3 W
R209	0225 1930	22K
R211	0225 1960	39K
R212	0107 1024	variable, 25K, ±20%
R213	0225 1870	6.8K
R214	0105 6060	variable, 50K, ±20%, ¼ W
R215	0223 7260	film, 150K, ±1%
R216	0230 4490	wire wound, inductive, 1K, ±5%, 3 W
R217	0225 1650	100
R218	0230 4510	wire wound, inductive, 1.5K, ±5%, 3 W
R219	0225 1810	2.2K
R220	0225 1700	270
R221	0225 1720	390
R222	0225 1530	10
R223	0225 1570	22
R224	0232 6010	wire wound, 300, 15 W
R225 & R226	0203 6800	22K, ±5%, 2 W
R227	0225 0400	470, ±5%
R228 & R229	0232 6020	wire wound, 1K, 15 W
R231	0203 7970	47K, 2 W
R232 A, B	0107 1261	variable, 10M, ±40%, ¼ W
R233	0225 2210	4.7M
R234 A, B, C	0107 1241	variable, 5M/2M/150K, ±30/20/10%
R235	0223 7260	film, 150K, ±1%
R236	0223 7230	film, 120K, ±1%
R237	0107 3900	variable, 10M, ±40%, ¼ W
R241	0223 7230	film, 120K, ±1%
R242	0107 3900	variable, 10M, ±40%, ¼ W
R243	0107 1024	variable, 25K, ±20%
R244	0225 1960	39K
R245	0225 0770	16K, ±5%
R246	0225 1650	100
R247	0230 4510	wire wound, inductive, 1.5K, ±5%, 3 W
R248	0230 4490	wire wound, inductive, 1K, ±5%, 3 W
R249	0225 1810	2.2K
R251	0225 1610	47
R252	0225 1530	10
R253	0230 4630	wire wound, inductive, 10K, ±5%, 3 W
R254	0225 1770	1K
R255	0225 1570	22
R256	0225 1790	1.5K
R257 & R258	0101 4840	variable, 10K, ±20%, 2 W
R259	0225 1530	10
R261	0107 1024	variable, 25K, ±20%
R262	0225 2050	220K
R263 & R264	0225 1530	10
R265	0225 1810	2200
R301	0225 1930	22K
R302	0107 1024	variable, 25K, ±20%
R303	0225 1930	22K
R304	0230 4060	film, 1080, ±2%, 13 W
R305	0225 1990	68K
R306	0225 2130	1M
R307	0225 2070	330K
R308	0225 1770	1K
R309	0105 6840	variable, 5K, ±30%, ¼ W
R310	0225 1980	56K
R311	0225 2250	10M
R312	0225 4970	47K, 1 W
R313 & R314	0225 1530	10
R315	0225 0310	200, ±5%
R316	0225 1530	10
R317	0225 1770	1K
R318	0225 0310	200, ±5%
R319	0225 1530	10
R320	0225 1770	1K
R321	0221 8040	wire wound, 750, ±5%, 10 W
R322	0225 1770	1K
R323	0225 0310	200, ±5%
R324	0225 1530	10
R325	0225 1770	1K
R326 & R327	0203 7550	15, 2 W
R328 & R329	0203 7530	10, 2 W
R331 & R332	0230 4050	film, 150, ±2%, 13 W
R333	0210 0650	wire wound, 1
R334	0211 3500	wire wound, 100, ±5%, 5 W
R335	0203 6060	18, ±5%, 2 W
R336	0203 7710	330, 2 W
R337	0225 1530	10
R338	0225 0890	51K, ±5%
R339	0225 1000	150K, ±5%
R341	0225 1970	47K
R342	0225 1990	68K
R343	0105 6830	variable, 100K, ±30%, ¼ W
R344	0225 1890	10K
R345	0225 2020	120K
R346 to R348	0225 1530	10
R401	0224 3490	film, 5.73, ±1%
R402	0224 3570	film, 215.2, ±1%
R403 & R404	0224 3490	film, 5.73, ±1%
R405	0224 3570	film, 215.2, ±1%
R406 & R407	0224 3490	film, 5.73, ±1%
R408	0224 3570	film, 215.2, ±1%
R409 & R410	0224 3490	film, 5.73, ±1%
R411	0224 3570	film, 215.2, ±1%
R412	0224 3490	film, 5.73, ±1%
R413	0224 3470	film, 2.87, ±1%
R414	0224 3580	film, 434, ±1%
R415	0224 3470	film, 2.87, ±1%
R416	0224 3430	film, 1.44, ±1%

Symbol	Part Number	Description
R417	0224 3600	film, 868.3, ±1%
R418	0224 3430	film, 1.44, ±1%
R419	0224 3540	film, 96.25, ±1%
R420	0224 3500	film, 71.25, ±1%
R421	0224 3540	film, 96.25, ±1%
R422	0224 3500	film, 71.25, ±1%
R423 & R424	0224 3540	film, 96.25, ±1%
R425	0224 3500	film, 71.25, ±1%
R426 & R427	0224 3540	film, 96.25, ±1%
R428	0224 3500	film, 71.25, ±1%
R429 & R430	0224 3540	film, 96.25, ±1%
R431	0224 3550	film, 142.5, ±1%
R432	0230 4140	film, 96.25, ±1%, 4 W
R433	0224 3550	film, 142.5, ±1%
R434	0230 4140	film, 96.25, ±1%, 4 W
R501	0223 9360	wire wound, 5K, 5 W
R502	0225 2130	1M
R503 & R504	0225 1730	470
R505	0225 1300	2.7M, ±5%
R506 & R507	0225 1530	10
R508	0225 1240	1.5M, ±5%
R509	0225 1190	910K, ±5%
R511 & R512	0225 1100	390K, ±5%
R513	0225 2010	100K
R514	0223 5530	film, 270K, ±1%
R515	0105 6820	variable, 25K, ±30%, ¼ W
R516	0224 3960	film, 160K, ±1%
R517	0230 4320	wire wound, inductive, 20, ±5%, 3 W
R518	0225 2090	470K
R519 & R520	0225 1770	1K
R521	0225 1300	2.7M, ±5%
R522	0224 4770	wire wound, 350, ±5%, 55 W
R523 & R524	0203 3080	22, ±5%, 1 W
R525	0225 1240	1.5M, ±5%
R526	0225 1190	910K, ±5%
R527 & R528	0225 1100	390K, ±5%
R529	0225 2010	100K
R531	0223 7260	film, 150K, ±1%
R532	0105 6820	variable, 25K, ±30%, ¼ W
R533	0224 3960	film, 160K, ±1%
R534	0225 1570	22
R535 & R536	0230 4490	wire wound, inductive, 1K, ±5%, 3 W
R537 & R538	0225 1770	1 K
R539 & R540	0203 3080	22, ±5%, 1 W

SWITCHES

(All rotary switches are phenolic and the angle of throw is 60° between positions unless otherwise specified)

Symbol	Part Number	Description
S101	0500 6793	push-push
S102	0501 1911	rotary, 30°, 4 sections, 6 positions
S103	0501 1921	rotary, 1 section, 3 positions
S201 & S202	0501 1971	rotary, 2 sections, 3 positions
S301	0501 1921	rotary, 1 section, 3 positions
S401 to S406	0500 6793	push-push
S407	0501 1901	rotary, 2 sections, 6 positions
S501	0500 1130	toggle, SPST

TRANSFORMERS

T101	2001 1080	pulse
T201	2002 0000	pulse
T202	2001 1080	pulse
T203 & T204	2002 0000	pulse
T501	2000 9982	plate
T502	2000 9972	filament

TUBES

V101	2500 8560	6BK7-A
V102	2500 1530	12AT7
V103	2500 0020	6AL5
V104 & V105	2500 8560	6BK7-A
V201	2501 1010	6463
V202	2500 0050	6AU6
V203	2501 1010	6463
V204	2500 8560	6BK7-A
V205 & V206	2500 2950	5687
V207	2501 1010	6463
V208	2500 8560	6BK7-A
V209 & V210	2500 2950	5687
V301	2500 7810	6BX7-GT
V302 & V303	2501 1190	6CB5-A
V304 to V306	2501 0250	6216
V307 & V308	2500 0020	6AL5
V309 & V310	2500 2950	5687
V311	2501 1010	6463
V312	2500 1530	12AT7
V501	2501 0200	6AS7-GA
V502 & V503	2500 1500	12AX7
V505	2500 1500	12AX7
V506	2500 0300	0A2
V507 & V508	2501 0200	6AS7-GA

CABLE

W501	5026 9641	assembly, power, #18/2 AWG, 72 inches

TABLE 4-3
ADJUSTMENTS TO BE MADE WHEN REPLACING TUBES

SYMBOL	TYPE	SERVICE ADJUSTMENTS TO BE CHECKED (See Table 4-2)
SYNCHRONIZER		
V101	6BK7-A	MAX RATE ADJ (R108)
V102	12AT7	—7.5V BIAS ADJ (R261)
V103	6AL5	None
V104	6BK7-A	V104 STAB (R117) and TRIG DELAY ADJ (R120)
V105	6BK7-A	None
TIMING AND PULSE GENERATOR		
V201	6463	V201 STAB (R206)
V202	6AU6	None
V203	6463	V203 STAB (R212) and 0.05 μsec (R214)
V204	6BK7-A	None
V205	5687	TURN-ON BTO BIAS (R257)
V206	5687	None
V207	6463	V207 STAB (R243); all pulse width calibration adjustments, includes: 1, 10, and 100 μsec (front panel); C218, C219, C221 and C223
V208	6BK7-A	None
V209	5687	TURN-OFF BTO BIAS (R258)
V210	5687	None
PULSE DRIVER AND OUTPUT		
V301	6BX7-GT	DRIVER SCREEN ADJ (R302)
V302 & V303	6CB5-A	Delay Line Adjustments (L301, L302, C304, and C313)
V304 to V306	6216	Delay Line Adjustments (L301, L302, C304, and C313)
V307 & V308	6AL5	None
V309 & V310	5687	INVERTER BIAS (R343)
V311 & V312	6463	INVERTER BIAS (R343)
POWER SUPPLY		
V501	6AS7-GA	+250V ADJ (R515)
V502	12AX7	+250V ADJ (R515)
V503	12AX7	+250V ADJ (R515) and +130V ADJ (R532)
V504	CH1068	+130V ADJ (R532)
V505	12AX7	+130V ADJ (R532)
V506	OA2	None

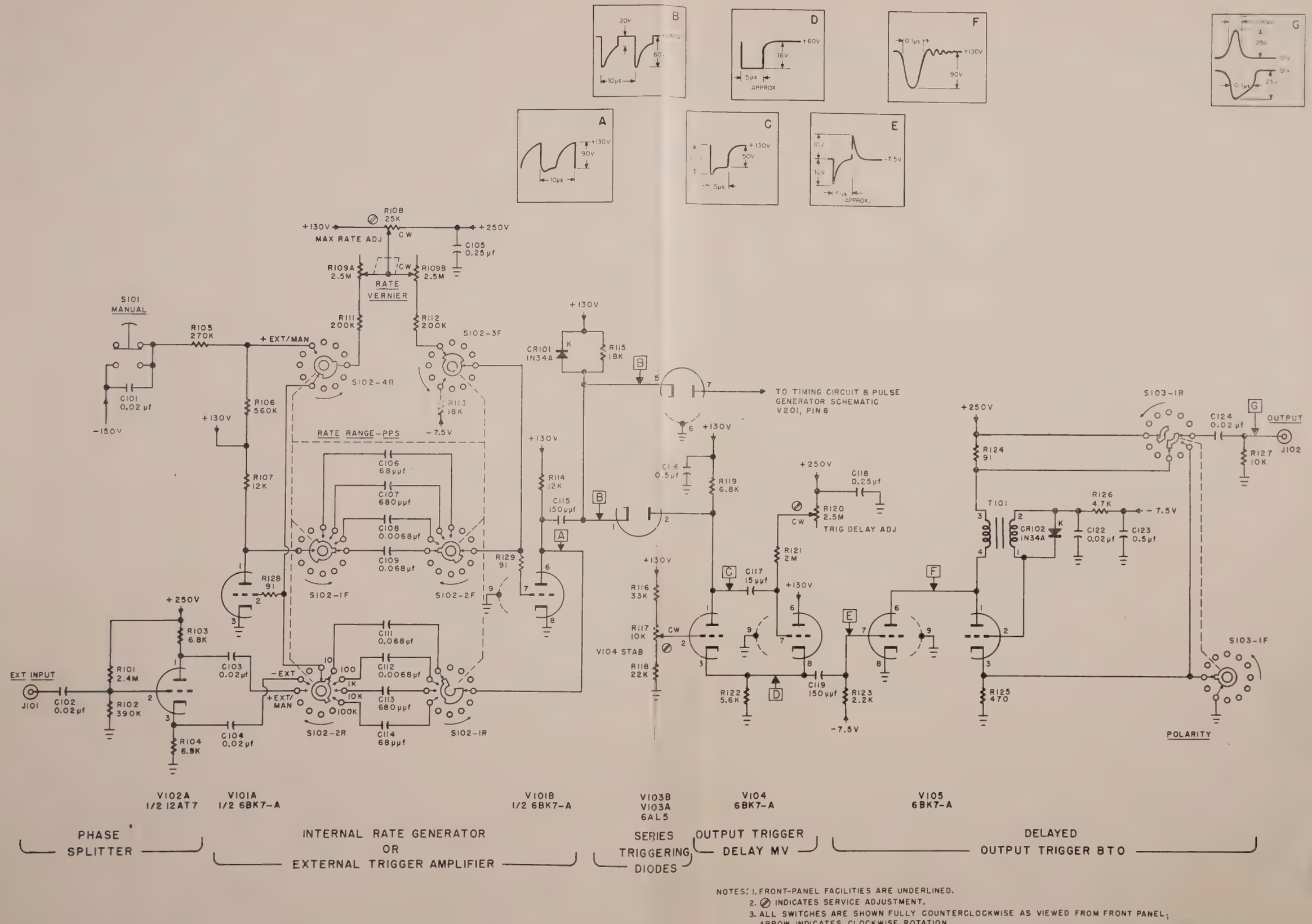
TABLE 4-2
SERVICE ADJUSTMENT CHART

PRECAUTION

DO NOT SET ANY SERVICE ADJUSTMENT WITHOUT FOLLOWING SPECIFIC INSTRUCTIONS AND SEQUENCE GIVEN IN TABLE 4-2. SOME ADJUSTMENTS ARE INTERDEPENDENT.

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
+250V ADJ (R515) Fig. 4-1	(1)	Connect a voltmeter from the insulated standoff next to V501 and ground. Adjust R515 for +250 volts
+130V ADJ (R532) Fig. 4-1	(1)	Connect a voltmeter from tie point on V504 socket and ground. Adjust R532 for +130 volts
—7.5V ADJ (R261) Fig. 4-2	(1)	Connect a voltmeter from pin 8 of V102B (negative) and ground. Adjust R261 for —7.5 volts
MAX RATE ADJ (R108) Fig. 4-3	(2)	R108 is used to set the maximum internal trigger repetition rate to 100,000 pps 1. Connect a properly terminated cable between trigger OUTPUT and the input of a cathode-ray oscillograph 2. Set RATE RANGE—PPS to 100K, RATE VERNIER fully clockwise, and POLARITY to + 3. Adjust R108 for an interval of 10 μsec between triggers as viewed on the cathode-ray oscillograph
V104 STAB (R117) Fig. 4-3	(2)	R117 is used to control the threshold bias of V104 1. Set TRIG DELAY ADJ (R120) fully clockwise 2. With an appropriate test probe connected to the input of a cathode-ray oscillograph, check waveform **D** while turning R117 clockwise 3. Set R117 to slightly below the point where instability occurs
V201 STAB (R206) Fig. 4-3	(2)	R206 is used to control the threshold bias of V201 1. Set TRIGGER POSITION μSEC fully clockwise 2. Check waveform **I** while turning R206 clockwise 3. Set R206 to slightly below the point where instability occurs
V203 STAB (R212) Fig. 4-3	(2)	R212 is used to control the threshold bias of V203 1. Set 0.05 μsec (minimum pulse width adjustment on front panel) fully counterclockwise 2. Check waveform **M** while turning R212 clockwise 3. Set R212 to slightly below the point where instability occurs
V207 STAB (R243) Fig. 4-3	(2)	R243 is used to control the threshold bias of V207 1. Set PULSE WIDTH MULTIPLIER to X10 and μSEC (vernier) fully clockwise 2. Check waveform **V** while turning R243 clockwise 3. Set R243 to slightly below the point where instability occurs
Delay Line Adjustments (C304, L301, C313, L302); DRIVER SCREEN ADJ (R302) Fig. 4-3	(2)	These adjustments are used to control the shape of the positive pulse 1. Connect a properly terminated cable from the PULSE OUTPUT terminal directly to the vertical deflection plates of a cathode-ray oscillograph

* Number shown ( ) corresponds to reference number of test equipment in Table 4-1



NOTES: 1. FRONT-PANEL FACILITIES ARE UNDERLINED.
2. ⊘ INDICATES SERVICE ADJUSTMENT.
3. ALL SWITCHES ARE SHOWN FULLY COUNTERCLOCKWISE AS VIEWED FROM FRONT PANEL; ARROW INDICATES CLOCKWISE ROTATION.
4. [A]→ LOCATES AND IDENTIFIES WAVEFORMS ON THIS SCHEMATIC.

Figure 5-1. SCHEMATIC, SYNCHRONIZER
DU MONT TYPES 404 and 404-R PULSE GENERATORS
(Reference Drawing 98001381-4, Sheet 1 of 5, Issue 5)

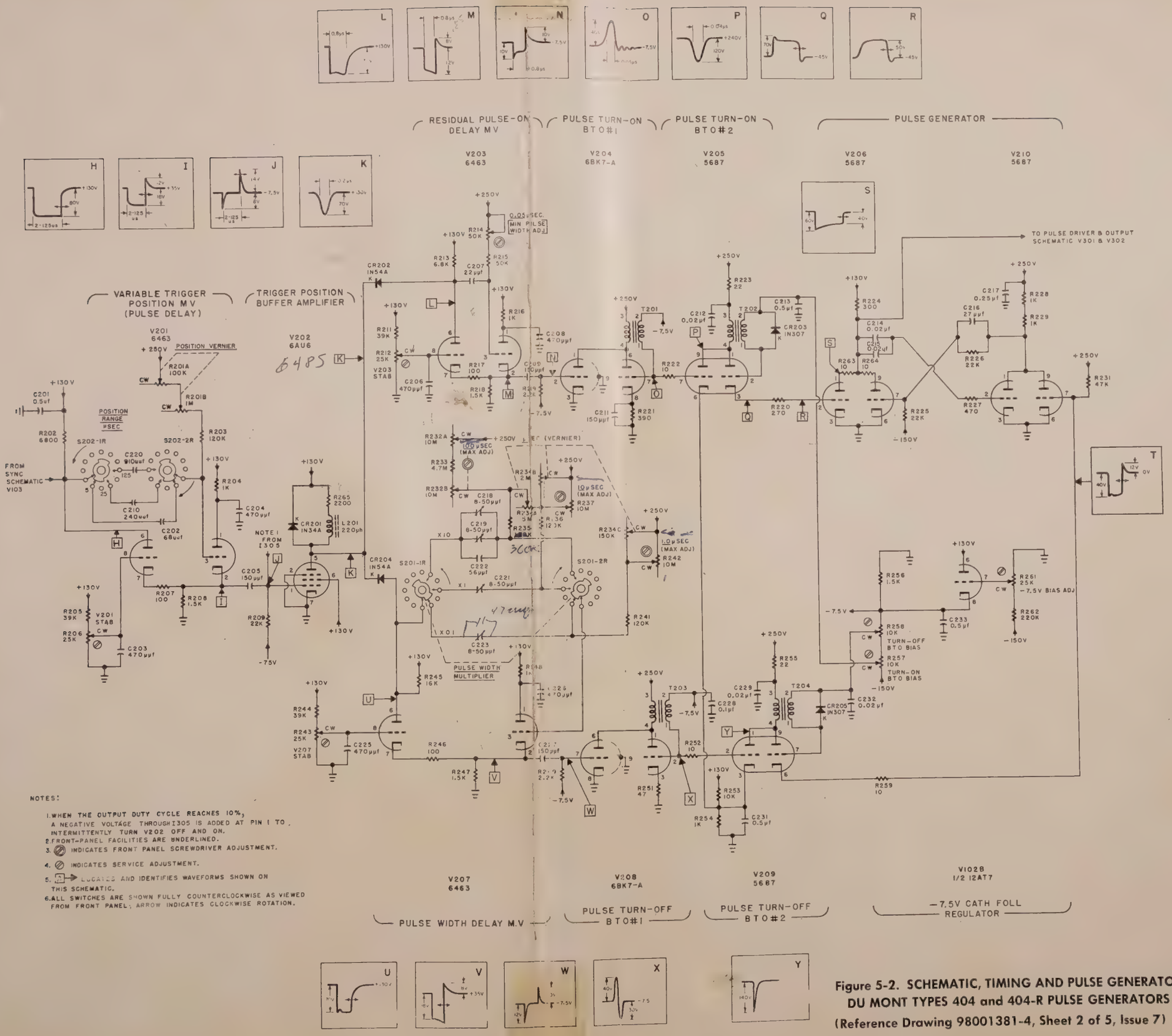
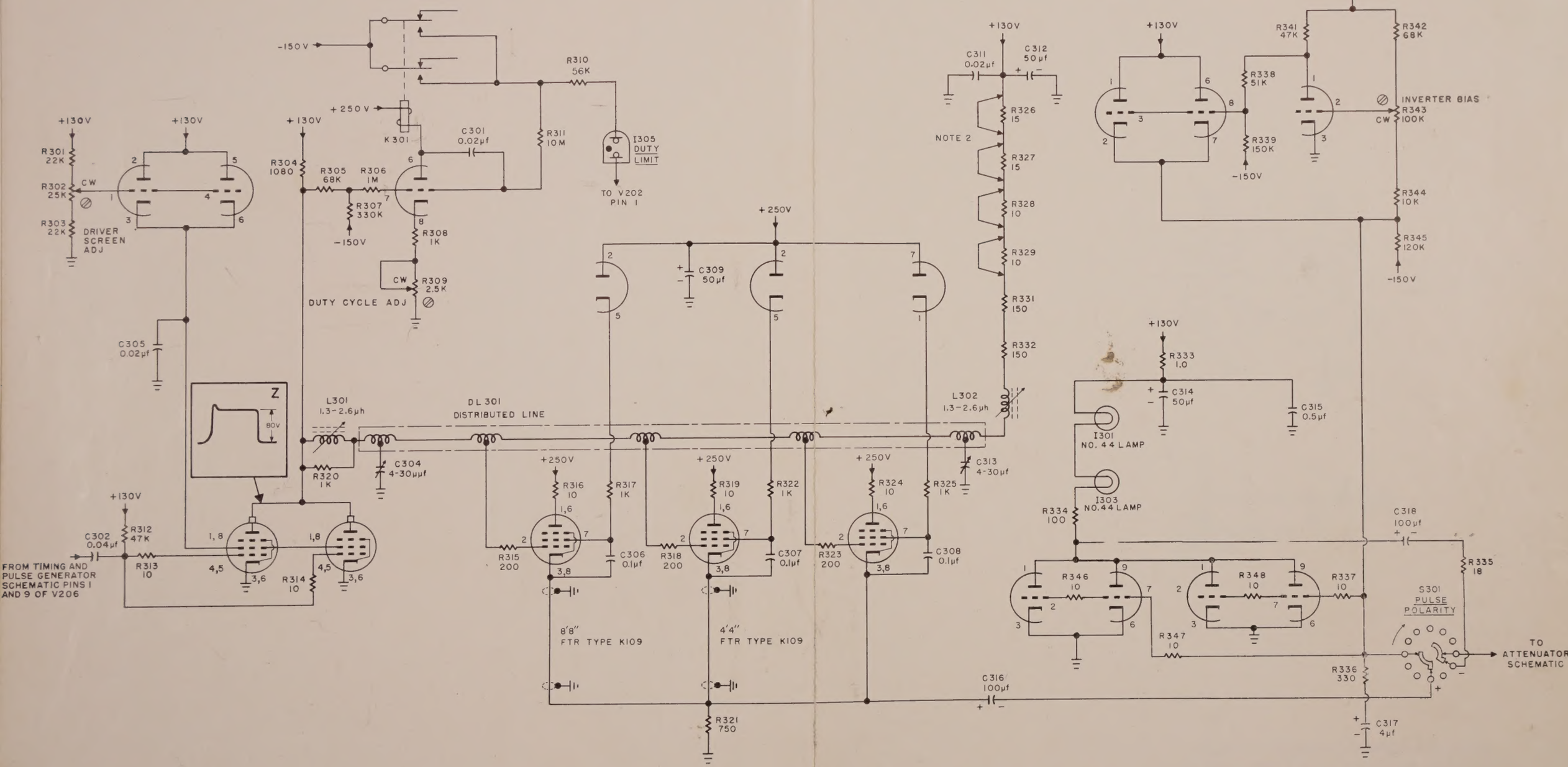


Figure 5-2. SCHEMATIC, TIMING AND PULSE GENERATOR DU MONT TYPES 404 and 404-R PULSE GENERATORS
(Reference Drawing 98001381-4, Sheet 2 of 5, Issue 7)



NOTES-1. ⊘ INDICATES SERVICE ADJUSTMENT
2. JUMPERS ACROSS R326 THROUGH R329 ARE ADDED OR OMITTED WHERE NECESSARY TO OBTAIN THE PROPER TERMINATION FOR DL 301
3. FRONT-PANEL FACILITIES ARE UNDERLINED

Figure 5-3. SCHEMATIC, PULSE DRIVER AND OUTPUT DU MONT TYPES 404 and 404-R PULSE GENERATORS
(Reference Drawing 98001381-4, Sheet 3 of 5, Issue 6)

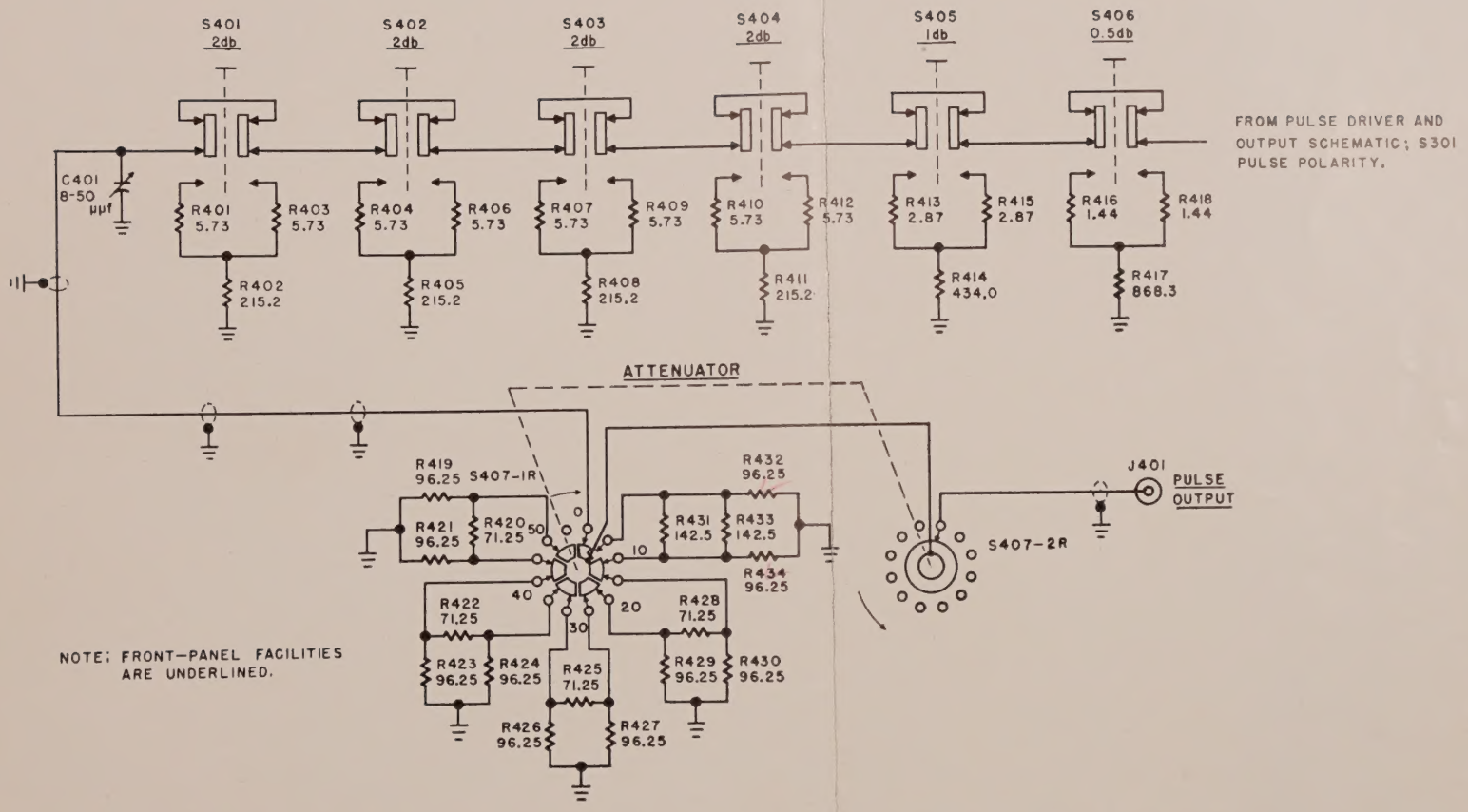


Figure 5-4. SCHEMATIC, OUTPUT ATTENUATOR DU MONT TYPES 404 and 404-R PULSE GENERATORS (Reference Drawing 98001381-4, Sheet 4 of 5, Issue 1)

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